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ART. XXXI.—*On certain recent contributions to Astro-Meteorology;* by H. A. NEWTON.

1. *Radiant points, or radiant areas.*

FOR more than twenty years a Committee of the British Association for the Advancement of Science has annually made an extended report on *Observations of Luminous Meteors*, in which have been given in detail the times, paths, physical appearances, and other phenomena, of meteors seen during the years immediately preceding. No special effort has been made until recently, to elaborate this mass of material. R. P. Greg, Esq., of Manchester, assisted by Mr. A. S. Herschel, at last undertook the task of plotting the paths contained in the voluminous records. By this means they have determined between fifty and sixty radiants, for different periods of the year. Prof. E. Heis of Münster, has in like manner, from observations made by himself and his assistants during a period of twelve years, deduced a similar and, to a considerable extent a corresponding series of radiant points. The latter series is in the Monthly Notices of the Roy. Astro. Soc., xxiv, 213. Both series are in the Report of the British Association for 1864, and in the Proceedings of the British Meteorological Society for Jan. 18th, 1865. From the latter source we give the following table. The general results of Mr. Greg's investigations as regards *meteor showers* are thus summed up in the Report of the Committee on Luminous Meteors.

"They appear to endure for almost any period, from twenty-four hours to eight or possibly ten weeks, differing from one another in rich-

Comparison of the epochs and positions of radiant-points of shooting stars, concluded independently by R. P. Greg, Esq., and Dr. E. Heis.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845-63. (R. P. Greg.)					Observed at Munster, 1849-61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant.		Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
				Right Ascension.	North Declination.				
				°	°		°	°	
1	Dec. 20–Jan. 30	20	ii	22	75	A_1	29	50	Jan. 1–15.
						A_2	15	63	Jan. 16–31.
2	Dec. 20–Jan. 30	13	ii *a*	5	85	N_1	285	84	Jan. 1–15.
						N_3	0	90	Jan. 16–31.
3	Dec. 21–Feb. 4	28	iii	68	17	AG_1			
4	Jan. 2–Jan. 3	52	i	234	51	K_2	235	52	Dec. 16–31.
						K_1	242	51	Jan. 1–15.
5	Jan. 2–Feb. 4	30	iv	133	40	? M_2	166	52	Jan. 16–31.
6	Jan. 5–Jan. 25	15	iv *a*	173	32	MG_1			
7	Feb. 4–Feb. 26	36	v	147	34	M_3	150	60	Feb. 1–14.
8	Feb. 7–Feb. 26	20	vi	136	70	M_4	130	63	Feb. 15–28.
9	Feb. 9–Feb. 17	13	vii	76	40	A_3	65	51	Feb. 1–14.
						A_4	91	37	Feb. 15–28.
10	Feb. 10–Mar. 17	21	viii	168	9	S_1	170	11	" "
						S_2	178	7	Mar. 1–15.
						S_3	173	23	Mar. 16–31.
11	Feb. 11–Mar. 16	10	viii *a*	37	1	SG_1			
12	Feb. 19–Feb. 26	10	vi *a*	220	84	N_3	0	90	Feb. 1–14.
						N_4	250	83	Feb. 15–28.
13	Mar. 3–Mar. 27	11	xiii	44	72	N_5	340	80	Mar. 1–15.
14	Mar. 3–Mar. 31	30	ix	145	67	M_5	125	52	" "
						M_6	140	50	Mar. 16–31.
15	Mar. 3–Mar. 31	18	x	186	58	? M_2	140	50	" "
16	Mar. 12–Mar. 20	20	xii	223	39	MG_2			
17	Apr. 1–June 2	52	xi	194	52	M_7	160	53	Apr. 1–15.
						M_8	150	61	Apr. 16–30.
18	Apr. 2–May 1	20	xiv	189	4	S_5	194	5	" "
19	Apr. 8–May 28	20	xix	227	−8	SG_2			
20	Apr. 12–Apr. 13	17	xvi	276	26	QG			
21	Apr. 16–May 3	30	xv	96	87	N_8	265	83	Apr. 16–30.
22	Apr. 19–Apr. 20	25	xvii	282	33	DG_1			
23	Apr. 25–June 4	28	xviii	255	48	DG_2			
24	Apr. 30–June 4	15	xx	243	20	Q_1	218	20	May 1–31.
25	May 9–June 3	16	xviii *a*	277	42	D			
26	May 9–June 4	8	xxi	286	21	W	292	15	June 1–30.
27	May 29–June 17	18	xxii	336	45	B_1	332	60	May 1–31.
						B_2	333	42	June 1–30.
28	June 1–June 30	9	xx *a*	236	30	Q_2	242	12	" "
29	June 1–June 30	12	xxiii	300	85	N_9	290	80	May 1–31.
						N_{10}	150	83	June 1–30.
30	July 2–July 24	51	xxiv	291	53	B_3	315	54	July 1–15.
				to 313	43				
31	July 10–Aug. 6	26	xxvii	257	13	Q_3	262	12	July 1–15.
32	July 20–Aug. 4	46	xxv	359	70	N_{11}	20	85	" "
						N_9	337	86	July 16 to Aug. 15.*
33	July 22–Aug. 10	70	xxvi	344	12	T_1	314	15	Aug. 16–31.
				to 327	10				
34	July 29–Aug. 22	123	xxiv *a*	302	44	B_4	306	59	Aug. 16–31.
				to 288 and 298	42 to 58	B_5	302	65	July 16 to Aug. 15.*

TABLE—continued.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845-63. (R. P. Greg.)					Observed at Munster, 1849-61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant. Right Ascension.	Position of radiant. North Declination.	Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
				°	°		°	°	
35	Aug. 6–Sept. 10	80	xxix	0	90	N_{12}	295	79	Aug. 16–31.
						N_{13}	130	84	Sept. 1–15.
36	Aug. 7–Aug. 16	...	xxviii	45	55	A_6	50	51	July 16 to Aug. 15.*
				to 20	62				
37	Aug. 17–Sept. 12	9	xxvii *a*	245	5	Q_2	262	12	July 1–15.
				to 262	12				
38	Aug. 17–Sept. 30	18	xxiv *b* or xxx *a*	282	42	B_5	293	57	Sept. 1–15.
39	Aug. 17–Sept. 30	150	xxx	333	50	EG			
				i.e. 314	52	E	330	50	Oct. 16–31.
				to 347	47	A_{11}	35	63	Sept. 1–15.
				and 333	41	A_{12}	44	63	Sept. 16–30.
				to 333	62	A_{13}	51	61	Oct. 1–15.
40	Aug. 18–Sept. 29	27	xxxi or xxx *b*	13	34	R_1	53	35	Sept. 1–15.
						R_2	46	37	Sept. 16–30.
41	Aug. 22–Nov. 5	27	xxxii	1	15	T_2	343	10	Sept. 1–15.
						T_3	1	11	Sept. 16–30.
						T_4	3	11	Oct. 1–15.
42	Sept. 6–Nov. 23	18	xxxiv	22	−9	TG			
						U	10	−11	Oct. 16–31.
43	Sept. 20–Oct. 11	35	xxxv	83	48	AG_2			
44	Sept. 25–Oct. 10	16	xxxvi	51	84	N_{14}	65	84	Sept. 16–30.
45	Sept. 27–Nov. 2	67	xxxiii	14	58	A_{14}	20	42	Oct. 16–31.*
						A_{15}	25	40	Dec. 1–15.*
46	Oct. 3–Oct. 20	11	xxxvii	140	45	LG			
						? L_1	115	55	Dec. 1–15.*
47	Oct. 4–Nov. 10	35	xxxviii	45	33	R_3	45	32	Oct. 1–15.
48	Oct. 18–Nov. 3	30	xxxix	83	12	O			
49	Oct. 20–Nov. 21	33	xl	91	56	F	75	40	Oct. 16–31.*
50	Oct. 31–Dec. 9	14	xliii	139	7	LH			
51	Nov. 1–Nov. 23	75	xli	16	49	AG_3			
52	Nov. 7–Nov. 15	...	xlii	153	22	L_6	150	28	Nov. 1–30.*
53	Nov. 23–Dec. 9	9	xlv	279	56	DG_2			
54	Nov. 24–Dec. 10	37	xliv	59	58	A_{16}	37	59	Dec. 16–31.
55	Nov. 26–Dec. 30	84	xlvii	96	36	G			
						? L_1	115	55	Dec. 1–15.*
56	Nov. 27–Dec. 19	10	xlvi	157	71	KG			

Total meteors, 1746; days, 1655; meteor-showers, 56.

(*) Radiants marked thus are extracted from the work by Dr. Heis, entitled 'Die Periodische Sternschnuppen.' (4to. Cöln, 1849.)

ness or intensity of display. In some there appears to be a tendency to maximum display on particular days, as for example xlvii, lasting from November 26th, to December 30th; but the most abundant display occurs from December 9th to 13th. In others no such maximum can be perceived. Their number, of fully fifty as yet ascertained, will probably not be much exceeded, unless by short-lived showers, and by others whose radiants culminate just before dawn. There is no confusion or

chance in their return, but, on the contrary, the showers are very regularly recurrent every year, and, allowing a *radiant-region* of 10° to 15° in diameter for each, the so-called "sporadic" meteors will become extremely scarce, now that the principal showers and their radiants have been pointed out. A well-marked instance of long persistence and remarkable for having its radiant very small and fixed, is the shower of August 6th to September 10th, No. xxix. The great majority have, at the present time, been as clearly defined (as regards the time of their occurrence, duration, and positions of their radiants) as in the case with the older and better known showers of August and November. On the average of many years, the radiant-regions of a few are, however, still very extensive. In all, a plane, oval, or double-headed region of radiation appears to represent the conditions of the showers more correctly than a point. This elongation of the radiant-region is in most cases perpendicular to the ecliptic, or parallel to the *via lactea*, in or near which the greater number of the radiants in the latter half of the year are placed. The meteors of particular showers vary in their distinctive characters, some being larger and brighter than others, some whiter, some more ruddy than others; some swifter, and drawing after them more persistent trains than those of other showers. Their connection with the epochs and directions of large meteors still remains to be established."

From a private letter by Mr. Greg to Mr. B. V. Marsh we learn that some minor changes are found neccessary, by further observation and investigation, in the duration of the showers and the places of the radiants. Mr. Greg's charts containing the paths of nearly 2000 shooting stars are about to be published by the British Association. We may hope to receive them within a few months. We evidently need these charts in order to discuss intelligently this important subject. While waiting for them, however, one or two remarks may not be out of place.

That the so-called *sporadic* shooting stars should belong largely to rings or streams, as do the August and November meteors, is in the present state of our knowledge probable, or at the least is not improbable. The reasonings of Mr. Schiaparelli, which will be spoken of further on in this article, strengthens this probability.

But we meet with some difficulty in accepting the proposition that a ring or stream may be of such breadth as to require eight or ten weeks for the earth to traverse it, that is, that the ring may extend 60° or 70° along the ecliptic; or rather, if there were so broad a ring or stream, it would not appear to have a radiant area so small, and so well marked, as to be detected.

The position of the radiant indicates that point of the heavens from which the *relative* motion of the meteoroids with reference to the earth is directed. This direction is the resultant of two *absolute* motions, that of the meteoroids and that of the earth. If either of these should change, the place of the radiant will change.

But during these eight or ten weeks the direction of the earth's motion would change 60° or 70°. If the direction of the meteoroids' motions were supposed parallel throughout the breadth of the stream, yet this change in the direction of the earth's motion alone appears to necessitate a change of the position of the radiant by a distance on the heavens of not less than 30° or 40°.

But for a group of such thickness, we can hardly suppose the absolute motions of the meteoroid parallel throughout its breadth. Each meteoroid must move about the sun in its own orbit, and though this is not entirely inconsistent with a parallelism of the paths where the group crosses the ecliptic, yet such a case is extremely improbable. Again it appears necessary that a meteoroid which is now on one side of the stream should be after half a revolution on the opposite side. Hence, we might reasonably expect that at the center of the stream we should find their paths crossing each other at large angles,—angles comparable in magnitude to the 60° or 70° which measures on the ecliptic the breadth of the stream. Such divergence of directions of the individual members of the group, would make the existence of an apparant radiant of moderate area impossible.

Again a stream whose thickness is so great, may be expected to have also large breadth in direction of the radius vector. This again would make the parellelism of the paths, and consequently the apparent radiation improbable.

In fact a ring of such enormous thickness as to require two months for the earth to cross it, would seem not only to lose all the essential characteristics of a distinct group, but also to be unable to manifest its existence by a constant and small radiant area.

The conclusions of Mr. Greg and Dr. Heis, are derived almost entirely from meteors seen in evening hours. But the phenomenon of radiation caused by parallelism of absolute motions should be more distinctly evident as the radiant is nearer the meridian. This occurs, in general, in the morning hours.

While, then, the existence of rings or streams is *a priori* probable, and so the existence of radiants for *very short* periods is to be looked for, yet the series now proposed will doubtless undergo essential changes, as we accumulate observations, or else some other cause than ring-formations be found to account for the radiation.

There should, in any case, be a tendency to a radiation, both from the zenith and from the point to which the earth is moving; hence from the region lying between these points, i. e., from the N.E. quarter of the heavens.

2. *Influence of the August and November meteors upon the temperature of the atmosphere.*

Erman early asserted the existence of cold periods, from the 5th to the 12th of February, and from 10th to the 13th of May. These he attributed to the influence of the August and November meteors, assuming that they passed at those epochs between the earth and the sun. To the same cause he attributed certain dark days, and other appearances, said to have occurred in the years, A.D. 1106, 1206, 1208, 1706, and 1547.

In a series of papers read before the Paris Academy of Sciences, and published in the Comptes Rendus,* Mr. Ch. St. Claire Deville has given the results of an elaborate investigation of the alleged abnormal changes of temperature in these months, as well as those alleged for corresponding days of August and November.

Mr. Faye in response to the first of these papers, shows conclusively that the dark days, &c., adduced by Erman, cannot be referred with any probability to the meteors as their cause.

In his earlier papers, Mr. St. Claire Deville undertakes to show that there are periodic variations of the temperature of the critical days in February, May, August, and November, that correspond to secular maxima and minima of the August and November meteors. For the August meteors he assumes a maximum in 1847 or 1848, relying upon the assertion of Mr. Coulvier-Gravier.

The existence of a maximum for the meteors in or near those years, is in itself exceedingly doubtful, and the evidence adduced by Mr. Deville to prove corresponding changes of temperature, is also very far from satisfactory.

Mr. Deville's own conclusions, as given in his later papers themselves throw doubt upon the existence of any important connection between the meteors and the temperature of the air. He finds that there is an accordance, between the movements of the thermometer in the several months, February, May, August, and November; and that the 12*th day* of each of these months is the critical day of a marked inflection. But this accordance (*or solidarity*) between the several months is entirely lost when the days are so combined as to compare not the days of the same name in the month, but those corresponding to points 90° apart on the ecliptic. But in what possible way can the meteors create oscillations in the temperature of the atmosphere, whose maxima and minima, shall in November be one or two days *before* we reach them, shall in May be at the time of the passage of the earth across the plane of the November group, in Au-

*. Vol. lx, 577, 655, 696, 909; lxi, 5, 61, 350; lxii, 1054, 1149, 1209, and lxiii, 1030.

gust shall be one or two days *after* the shower, and in February five or six days *after* the earth crosses the plane of the August ring?

3. *The paths and probable origin of Shooting Stars.*

The most important recent contribution to the theory of shooting stars is by Mr. Schiaparelli of the Brera Observatory at Milan. It is contained in a series of five letters to P. Secchi, published in the Bullettino Meteorologico of Rome.*

By a course of reasoning similar to that which led the writer to the same conclusion,† he argues that the mean velocity of the meteoroids, is considerably greater than that of the earth in its orbit. Hence their orbits are in general, long ellipses, or parabolas.

Assuming then (which is not improbable) that the meteoroids form in the planetary spaces a multitude of currents, or continuous rings, having all possible inclinations to the ecliptic, he proceeds to inquire in what way so singular a form of grouping of cosmical matter, could have been produced.

Notwithstanding the uncertainty of the determinations of the velocity of the solar system and of the stars in space, he considers it reasonable to assume that the velocities relative to the sun of the various bodies which are scattered through stellar spaces, are comparable in magnitude to those of the planets in their orbits.

Suppose now one of these bodies, a comet for instance, to come by its proper motion so near to the sun, that solar attraction far exceeds the attraction of the stars, and yet to be at such a distance that its annual parallax is but a few seconds. Its orbit about the sun will then be a conic section. Suppose now the sun to be at rest, and regard the relative velocity of the comet as the real velocity. Let fall a perpendicular from the sun upon the direction of the comet's motion. The area described about the sun in a unit of time, will be equal to one-half the product of this perpendicular into the comet's velocity.

As, however, the velocity is, in general, comparable in magnitude to the planetary velocities, and the perpendicular is in general, enormously greater than the distances of the planets from the sun, it follows that the areas described in a unit of time are, in general, very much larger than corresponding planetary areas. But these areas are as the parameters of their corresponding orbits. Hence, in general, the orbits of such comets would have enormous dimensions in every direction, and the bodies themselves would remain invisible to us, because of their great distance from the earth.

* Vol. v, Nos. 8, 10, 11, 12, and vol. vi, No. 2.

† This Journal, xxxix, 205–7, and Mem. Nat. Acad. of Sciences, vol. i, p. 309–311.

In two cases only would they come within our field of vision. When the perpendicular is very small, a hyperbolic orbit would result, differing in general not much from a right line. As the radius of the sphere of our vision is only about four times the distance from the earth to the sun, this case would rarely happen.

The second case is when the relative motion of the comet is very small, that is, when the comet and sun are moving in nearly parallel paths, with nearly equal velocities. An orbit very nearly a parabola would result. This case would likewise be very rare, since of all possible velocities of the bodies in the stellar spaces, very few would be nearly equal and parallel to that of the sun.

The parabolic form of the cometary orbits should not then surprise us. This is not the only possible form. On the contrary it is one that is very rare. But owing to the nature of comets, and to our feeble powers of vision, we can see only those which describe just these orbits. Nor is there reason for wonder that the planes of their orbits have no relation to the plane of the ecliptic.

The characteristics peculiar to planets can be accounted for by their formation in the solar system; those peculiar to the orbits of comets depend on the manner in which the sun attracts them to itself from the depths of space. The latter then should have an origin foreign to our system. To which of these two classes belong the shooting stars? Are they planets, or are they comets?

The planetary hypothesis has hitherto been favored by astronomers. The ring theory, however, as Mr. Schiaparelli believes, leads to serious difficulties respecting the origin of the shooting stars, whether the rings be regarded as integral parts of the solar system from the beginning, or they be supposed to have come from space, being attracted hither by the sun.

There are two arguments which show that the meteoroids should be classed with the comets as originally strangers to our system, rather than with the planets. The first is that their orbits seem to be inclined at all angles to the ecliptic;* the second, that their velocity requires a long if not a parabolic orbit.

* That the inclinations of the orbits of the meteoroids are of all magnitudes, Mr. Schiaparelli infers, principally, from the positions of the radiants given by Messrs. Greg, Herschel, and Heis. Although these radiants are open to criticism, yet the above conclusion is undoubtedly true. It is readily seen that if the orbits of the meteoroids are but little inclined to the earth's orbit, the apparent paths of the meteors should themselves rarely be seen to cut the ecliptic, and that the paths produced forward should rarely cut the ecliptic above the horizon. In other words, the paths as seen in the sky should, with rare exceptions, appear to lead away from that circle. So far as my own observation is concerned, I find no such regularity. The meteors go toward the ecliptic as often as from it. Apparent radiation from points of such considerable latitude as those given in the table on pp. 286, 287, shows also that many of the orbits of the meteoroids, at least, are inclined at large angles to the earth's orbit.

Admit, then, that the shooting stars come from stellar space, and we have no longer closed rings of short period, but streams of a parabolic form, for which the period of revolution, if there is one, is very great. Now this parabolic current, which at first seems so strange a form, is not only possible, but it is the *only* form in which a cosmical cloud drawn from stellar space by solar attraction can approach the sun and become visible to us.

To prove this, he supposes a cosmic cloud of the size of the sun, to be at first at a distance equal to 20,000 (the mean distance from the earth to the sun being unity). The rarity of the matter in this cloud is regarded such that the mutual attraction of the particles may be disregarded. This cloud of particles is then supposed to have a velocity (relative to the sun) perpendicular to a line drawn to the sun, one twenty-thousandth of the mean velocity of the earth, or about one hundred yards a minute.

The several particles will move in elliptic orbits about the sun, but these ellipses will not be exactly equal. Mr. Schiaparelli shows that a cloud, of spherical form at first, would be deformed, little by little, and ultimately drawn out so as to have a very small transverse section. It will now lie along a parabolic arc, of which the sun is the focus. When the particle originally at the center of the globe reaches its perihelion, at a distance from the sun equal to $\frac{1}{2}$, the anterior portion of the group will have passed its perihelion 193·5 days, and have already crossed in its outward course the orbits of the minor planets. The end of the group will not have reached these orbits in its descent to the sun. The whole extends along 267° of anomaly on the parabolic orbit. The breadth of the group at its center, in direction of the radius vector, will be 96 meters, and in the direction perpendicular to the plane of the orbit, 37 kilometers. Its density at this place will be 400 millions of times the density of the original group.

If the primitive form of the group was other than spherical the same reasoning would apply, and similar results follow.

The apparent diameter of the assumed globe, as seen from the sun, is about 0″·1. But if the original cloud be supposed to have an apparent diameter of one minute, the resulting stream would require 636 years to pass the perihelion. Some of the nebulæ have apparent diameters exceeding that of the sun. A globe of such a size (1924″) would be transformed into a parabolic stream which would require more than 20,000 years to pass the perihelion. The cross section of this stream would be much greater than in the preceding case, but yet not so great but that the earth might cross it in a few hours, or at most, in one or two days. We may, then, without extravagant hypotheses account for the existence of meteoric currents which have been observed for hundreds or thousands of years, like that of August.

For facility of reasoning, the original position of the supposed spherical group was placed at the aphelion of a long ellipse. But results similar in kind, and comparable in degree, would result, had the group been supposed at any point of a conic section of very great length.

If the orbit is an ellipse, the original form of the cloud would never be regained. At each perihelion passage, the length of the stream would be increased until it formed a closed circuit. The stream would be, at first, periodic, but finally constant. If the orbit is open, there would be a single passage only.

The supposed cloud was deemed to exert no sensible attraction upon its particles. To justify such an assumption, Mr. Schiaparelli makes an estimate of the density of the August ring. For the mean distance from each other, of the bodies of the August group, he obtains by computation about 100 (geographic) miles. This is obtained by quite arbitrary suppositions, but the result is very nearly that which is obtained by computations from the best data in our possession (see this Journal, xxxix, 207), combined with observations at Hartford in 1863, when six observers counted 153 different meteors in a half hour.*

For the size of the individual meteoroids, he assumes one gram, relying upon the conclusions of Mr. A. S. Herschel who compared the light of the meteors with the light of a candle, and hence inferred their weight. The estimate seems too small, for some of the trains fill cubic miles of space with matter of sufficient consistency to form a cloud visible for minutes (see this vol., p. 86). Yet the probable size of these bodies is so small that Mr. Schiaparelli's reasoning is still conclusive.

To each sphere whose radius is fifty miles he assigns, therefore, one gram of matter. The cloud first supposed had only $\frac{1}{1000}$, $\frac{1}{1000}$, $\frac{1}{1000}$ the density of the resultant stream at the perihelion. Suppose, however, the space originally occupied by the meteoroids of the August stream, to be only one million times that now filled at the place where the earth traverses it. To each gram of matter would originally have belonged, in that case, a volume equal to that of a sphere 10,000 miles in diameter.

He then shows that a spherical group of bodies, each body weighing one gram, whatever be the dimensions of the group, must have at a distance from the sun equal to the earth's mean distance, a density such that the mutual distances of the members shall be less than 1·86 meters (2 yards), in order that the attraction of the sun shall not dissolve the group. If the mutual distances of the members exceed 1·86^m, the sun acts to separate the individuals from each other, not at the surface simply, but throughout the whole extent of the system.

* The corresponding mean distance from each other of the members of the November group, where we crossed it last year, is 30 or 40 miles.

But if the mutual distances are, as before determined, 100 miles, the dissolving power of the sun is 10^{15} times the mutual attraction of the particles. In like manner, the dissolving power of the sun's attraction upon a group of similar bodies distant 20,000 from the sun, the mutual distance of the bodies being 10,000 miles, is 125,000,000 times the attraction which the group has for one of its particles. This latter force then may be safely neglected. The dissolution or deformation of the system must, moreover, begin much farther away from the sun than the assumed position of the cosmic cloud, out even in the stellar spaces. It can enter the solar system only as a parabolic current.

Even if we suppose a group that is tolerably dense, approaching the sun, as, for instance, a comet without a nucleus, there is a certain limiting distance within which the differences of solar attraction tend to dissolve it. If such a group passes this limit, in its descent to perihelion, the members will be scattered, and the original formation will never be restored. We have thus a most singular effect of attractive force, namely, the dispersion of a system that lacks coherence.

If now a dense cloud of bodies is supposed to pass near one of the larger planets, its orbit will be changed, and may become one of short period, like those of certain comets. If, moreover, its perihelion distance is less than the distance at which solar attraction disintegrates the groups, the cloud is dissolved into independent particles. Diversity of planetary perturbations produces in the orbits of these particles a variety of elements, especially variety in the periodic times. The group is gradually lengthened along the ellipse, and after a certain number of revolutions the cloud becomes a continuous ring. The meteors of November belong to such a group, while the ring is partially formed. The August meteors probably represent a group after it is transformed into a continuous ring.

Mr. Schiaparelli gives a summary of the consequences which result from the preceding discussions in the following propositions, which establish the basis for a new theory of falling stars.

"I. Matter is disseminated in celestial space in all possible grades of division. The first grade consists of the larger stars, either isolated, or collected in systems of few members. The second is made up of large agglomerations of small stars, the *star dust* of Herschel, into which many nebulæ are seen to be resolved by large telescopes. Then follow smaller bodies, which are invisible except when they approach the sun under the form of comets. Finally the last grade consists of cosmical clouds, composed of very minute elements, which have a weight comparable to that of objects which we are accustomed to handle or transport on the earth.

"II. This last class of bodies may have been formed in space, by the local concentration of the celestial matter, in a manner analogous to the crystallization of substances chemically dissolved in liquids. From what

occurs in these crystallizations we are even led to think that such a form of aggregation is much more probable and more frequent than the others, which take place by large masses. Hence the volume occupied by the cosmical clouds may be a notable fraction of the stellar space.

"III. The movements of such clouds among the bodies of the universe, are comparable to those of the fixed stars, and are probably due to analogous causes. When any one of them enters the sphere of attraction of the sun, it cannot be visible to us unless its orbit relative to this great luminary is a very greatly elongated conic section.

"IV. Whatever may be the form and extent of a cosmical cloud, it cannot (with very rare exceptions) penetrate to the interior of the solar system, unless it has been transformed into a parabolic current, which may consume years, centuries, and myriads of years in passing, part by part, its perihelion, forming in space a river, whose transverse dimensions are very small with respect to its length. Of such currents, those which are encountered by the earth in its annual motion, are rendered visible to us under the form of showers of meteors diverging from a certain radiant.

"V. The number of meteoric currents crossing the spaces of the solar system, at all possible distances, and in all directions, is probably very great. The exceeding rarity of the matter contained in them, allows these currents to intersect mutually, without causing any disturbance to one another. They may undergo progressive transpositions and deformations in space, like rivers which slowly change their bed. They may be interrupted, and thence become double or multiple, and they may even in particular circumstances become closed elliptical rings. The November meteoroids are apparently portions of such a ring in process of formation.

"VI. The cosmical clouds having short periods of revolution around the sun, by which some are inclined to explain the appearance of shooting stars, cannot have a permanent existence without violating the known laws of universal gravitation.

"VII. The matter of the parabolic currents, after having passed the perihelion, returns into space in a state of dispersion, greater than that which it had before the passage. In particular cases, as when the current meets a planet, very great perturbations may ensue, and a separation of some of the meteoric stars into special orbits. Such stars from that moment may be called truly *sporadic*.

"VIII. Thus the meteoric stars, and other celestial products of analogous nature, which in past ages were commonly regarded as atmospheric phenomena, which Olbers and Laplace first ventured to make to come from the moon, and which at a later period were raised to the dignity of members of the planetary system, truly belong to the category of the fixed stars; and the name *falling stars* expresses simply and precisely the truth respecting them. These bodies have the same relation to comets, that the small planets between Mars and Jupiter have to the larger planets. The smallness of the mass is in each case compensated by the very great number.

"IX. Since we may safely regard it as certain that falling stars, bolides, and aërolites differ in nothing except their magnitude, we may conclude

that the matter which has fallen from the sky is a fragment of that of which the stellar universe is formed. And as in such matter there is no chemical element that is not found upon the earth, the similarity of composition of all the visible bodies in the universe, already rendered probable by researches with the spectroscope, acquires a new argument for its credibility."

The further question is then broached, whether it is necessary for the original cloud to be made up of such small elements; whether, for example, it may not consist of a moderate number of comets. In such a case, we ought to meet, from time to time, with orbits somewhat unlike, which intersect each other in the depths of space, but which lose the characteristics of a common system, owing to considerable intervals between the times of perihelion passage.

The question is not a new one. Prof. Hoek of Utrecht has found several double and triple systems of comets,* which at a remote epoch were near each other in space, although their perihelion passages have differed by years. The most notable of these systems, is that of the comets 1860 III, 1863 I, 1863 VI, which at the end of the year 760, A. D., were at distances from the sun respectively 600·00, 600·42, and 600·25, and distant from each other 12·8, 16·3, and 8·1. To a spectator from the sun their apparent maximum distance was 1° 33′. Hoek believes that the comets of 1677, and of 1683, belong also to this system. The antecedent probability of a chance coincidence like that of these comets is exceedingly small.

We find thus analogies between the systems of shooting stars, and systems of comets. Can we not imagine mixed systems, in which a cloud of meteoroids are grouped in space about one or more larger nuclei, that is, about one or more comets?

If a system of this kind is drawn from solar attraction into the figure of a parabolic current, the parabola described by the principal body (or those described by the principal bodies) should evidently differ very little from the line along the center of the parabolic stream, consequently the preceding question is answered affirmatively whenever we find a meteoric current forming a parabola identical in magnitude and position with any parabolic cometary orbit. In such a case the comet will evidently form part of the current, and be one of its elements.

To test this question, Mr. Schiaparelli computed the following elements of the mean orbit of the August meteors, supposing it a parabola, assuming the radiant to be R. A. 44°, N. Dec. 56°, and the time of crossing the center of the group in 1866 to be Aug. 10·75. With these elements are placed those of the comet 1862 III, according to the latest determination of Dr. Oppolzer.†

* Monthly Notices, xxv, 243, and xxvi, 1 and 204. † Astr. Nach., No. 1384.

	Elements of August meteors.	Elements of Comet 1862 III.
Long. of perihelion,	343° 38′	344° 41′
Long. of node,	138° 16′	137° 27′
Inclination,	64° 3′	66° 25′
Perihelion distance,	0·9643	0·9626
Motion,	retrograde	retrograde
Perihelion passage,	July 23·62	Aug. 22·9, 1860
Period,		123·4 years

These elements do not differ by quantities greater than can be accounted for by the want of precision in the data for computing the paths of the meteors. We come thus to the unexpected conclusion, *that the great comet of* 1862 *is nothing else than one of the August meteoroids, and probably the largest of them all.*

At the time of announcing this relation of the comet of 1862 with the August meteors, Mr. Schiaparelli found no comet having similar relations with the November meteors. But upon the publication by Oppolzer shortly after,* of the corrected orbit of the comet 1866 I, the resemblance of its elements to those of the orbit of the November group on the supposition of a period of 33·25 years was strikingly manifest, attracting at once the notice of several astronomers.† The following comparative elements are given by Schiaparelli (Bullettino Meteor., Feb. 28, 1867).

	Nov. Meteors.	Comet 1866 I.
Perihelion passage,	Nov. 10·092, 1866.	Jan. 11·160, 1866.
Passage of descending node,	Nov. 13·576	
Long. of Perih.,	56° 25′·9	60° 28′·0
Long. of Asc. Node,	231° 28′·2	231° 26′.1
Inclination,	17° 44′·5	17° 18′·1
Perihelion dist.,	0·9873	0·9765
Eccentricity,	0·9046	0·9054
Semi-major axis,	10·340	10·324
Periodic time,	33·250	33·176
Motion,	retrograde.	retrograde.

The comet of Tempel, he adds, not only describes, therefore, the same orbit as the November group of meteoroids, but is in the same portion of the orbit, and probably nearer the head than the tail of the group.‡ The observations of November 13th, 1865, showed that the earth traversed the anterior portion of the swarm at that time. Two months later the comet passed the node, and ten months afterward the earth, returning to the node, encountered a dense portion of the stream.§

* Astr. Nach., No. 1624.

† Peters, Astr. Nach., No. 1624; Oppolzer, ibid. No. 1626; Schiaparelli, ibid.

‡ The computed elements of the comet of 1366, though very uncertain, resemble those of comet 1866 I, and may belong to the same body. There was a remarkable star-shower in 1366 shortly after the computed perihelion passage of the comet.

§ The total length of the stream would exceed 500,000,000 miles.

The comet 1862 III (sometimes called 1862 II by not counting Encke's comet), which seems thus to have such interesting relations with the August meteors, was discovered on the evening of the 18th of July, 1862, by Mr. H. P. Tuttle at Cambridge, Mass., and a little later on the same evening by Mr. Thomas Simons at Albany, N. Y.* It was first seen in Europe on the 22d of July, and remained visible more than two months. At its brightest its nucleus was equal to a star of the second or third magnitude, and its tail, according to some observers, was as much as 25° in length. The changes that took place in the coma and tail were quite remarkable, and were carefully observed. They will now possess a double interest.

The telescopic comet 1866 I was discovered by Tempel on the 19th of December, 1865, and was visible about a month. Its minimum distance from the earth's orbit was ·00660, about two and a half times the distance from the earth to the moon. This distance for Tuttle's comet is ·00472, or about 430,000 miles.

4. *Age of the November group of shooting stars.*

In the Paris Academy of Sciences, Jan. 21st, 1867, LeVerrier spoke of the November meteors (Comptes Rendus, lxiv, 94). Inasmuch as the group is not a complete ring, he argues that it is of comparatively recent formation, having come into the solar system, and been turned into its present orbit within a few centuries.

Now a body coming from a great distance and so having a great velocity in the vicinity of the earth could not be thrown into an orbit nearly circular by the feeble action of the lower planets. Computation leads to this result, which is fully confirmed by the fact that the swarm passes every 33 years near the earth and yet returns at *regular* intervals.

Assuming then an orbit whose period is $33\frac{1}{4}$ years, whose perihelion distance is 0·989, viz., the earth's distance from the sun on the 14th of November, and assuming the position of the radiant to be long. 142°, N. lat. $8\frac{1}{2}$°, he computes corresponding elements.

The group, when it came into the system, could not be thrown into its present orbit except by a powerful perturbing cause, as was the case with the comet of 1770. Moreover, comets so acted upon that the newly acquired orbit has a small perihelion distance, return necessarily to the orbit of disturbing body, just as the comet of 1770 returned to Jupiter. We cannot help then being struck with the circumstance that the November group extends to the orbit of Uranus and a very little farther; and

* Mr. Swift, of Marathon, N. Y., claims to have seen it two or three days earlier, but he made no announcement of the discovery, supposing it to be another comet.

that these orbits intersect, very nearly, just after the group passes its aphelion, and above the plane of the ecliptic.

The question then arises whether the group and Uranus have ever been together at this point. By calculation it is found that no such meeting could have taken place since the year 126 of our era, and that by a change of the computed node for that epoch by 1° 48′, and by placing the perihelion 4° from the descending node in November, the group would then actually strike the planet Uranus. These two changes are not greater than the possible errors of our observations.

LeVerrier's researches farther show that a globular group one-third of the diameter of Uranus (more or less) might at that time have been then thrown into a shape and an orbit which should by this time give all the phenomena of the November meteors. Its previous orbit might have been an ellipse, a parabola, or a hyperbola. Its motion might even have been direct in an elliptic or parabolic orbit.

In the course of future time, he argues, the phenomena will extend over a larger and larger number of consecutive years, diminishing, at the same time, in intensity. But no change in perihelion distance will make them disappear entirely. Even if this group again meets Uranus, the planet can act only upon a part of its matter, and cannot throw it all into a new orbit as Jupiter did the comet of Lexell.

These reasonings of Schiaparelli and LeVerrier have certainly great force, and make it probable that of the five possible periodic times of the November meteors (this Journal, xxxviii, 57), that of 33·25 years is the true one. The strongest objection to this conclusion is that the radiant in November does not seem to be a point, but rather a small area. This area cannot be of great breadth in latitude since the ring is only twenty-five or fifty thousands of miles in thickness. If, as observations *seem* to require, the radiant extends in longitude two or three degrees only, then the lines of apsides of the orbits of the several members of the group differ considerably. In this case it is more reasonable to suppose the orbits themselves grouped about an exact circle than about a long ellipse.

If upon examination it shall be found that the center of the radiant area was decidedly more or less than 89½° from the sun, on the morning of the 14th of November last, then this objection will lose much of its force. Again, if there shall not be seen on the morning of May 12th, 1867, between 1 o'clock and dawn, a few scattering members of the November group, radiating from a point 180° from Leo, this also will tend, to a certain extent, to strengthen Schiaparelli's reasonings.

ART. XXXII.—*Observations upon the Drift phenomena of Southwestern Iowa;* by C. A. WHITE, M.D.

[In advance of his final report upon the Geology of Iowa.]

IN the year 1858 I discovered distinct glacial scratches upon an exposed layer of the Upper Burlington limestone (Subcarboniferous), and made full notes and drawings of the same, which having been unfortunately destroyed by fire within a year afterward, no account of the observations was ever published. No opportunity has since presented itself to verify those observations, but I think I am not mistaken in the recollection that there was but one set of scratches, which were straight, distinct, and rather numerous; having a direction south, about twenty-two degrees east. This, so far as I am aware, was the first observation of glacial scratches upon rocks *in situ* in the state of Iowa, although boulders with similar scratches upon them are often seen in various parts of the state.

During my official labors last season, although considerable attention was given to the drift deposit, no similar traces of glacial phenomena were ever discovered until I reached the Missouri river in Mills county, where, on section 16, township 71, range 43, west of the fifth principal meridian, very distinct glacial scratches were found upon limestone of the Upper Coal-measures, not far from the middle of the series.

The locality is upon the western abrupt slope of the bluffs which border the bottom land of the Missouri river. The river being distant nearly three miles to the westward, the exact height of the scratches above it was not definitely ascertained, but it is probably not much less than one hundred feet above the ordinary stage of water. About four feet in thickness of ordinary drift material rested upon the striated surface. This had been partially removed by the quarrymen, exposing the scratches to view. Resting upon this light deposit of drift, and sloping upward to the high lands, are about one hundred and fifty feet of that peculiar lacustrine deposit called by Dr. Owen "siliceous marl," and by Prof. Swallow the "Bluff formation," which deeply covers the drift and underlying rocks of this region, except where they have been exposed by fluviatile denudation.

The boulders and pebbles contained in the drift material of this locality were both granitic and metamorphic. They were well rounded and worn, and striated faces were observed upon quite a number of them, thus as nearly as possible detecting them in the very act of scoring the rocks *in situ*.

The scratches here are in two sets, a coarser and a finer; those of the latter more numerous than the former, but those

of both sets being perfectly parallel with their fellows, distinct and straight. The surface of the rock had been ground level and smooth, removing all unevenness of the natural bedding surface. The directions of the striæ were determined by a very good pocket compass. That of the coarser set (No. 1) was found to be S. 20° E., and that of the finer set (No. 2) S. 51° E. No allowance was made in either case for the variation of the magnetic needle, which the local surveyors calculate at about eleven degrees east of north.

At an exposure of the same limestone one mile below Omaha, the capital of Nebraska, immediately upon the right bank of the Missouri river, and only some six or eight feet above the ordinary stage of water, other scratches of a similar character were observed. They were found upon the upper surface of a firm layer, which the workmen had exposed and were removing for building purposes. Here, however, there is but one set of scratches, their direction being S. 41° W. (set No. 3), not allowing for variation of the magnetic needle. The surface of the rock is nearly or quite level, but the roughness of the natural bedding surface has not been entirely removed, yet the striæ were so distinct that no difficulty was found in ascertaining their true direction.

The drift at this locality is principally composed of a dark colored, stiff, clayey material, intermixed with sand, gravel and boulders, and varies from one foot to eight feet in thickness. Upon this rests the bluff formation as before described. The face of the bluff at the locality where the latter observations were made is nearly at right angles with the direction of the striæ.

Considering that the whole region surrounding these localities, and for a long distance to the northward of them, is an entirely open country; that the present prominently uneven features of the region had their origin at a period subsequent to the drift; and the extreme simplicity and uniformity of the strata over which the glaciers must have moved, the direction of their currents which these scratches apparently indicate seems very remarkable. We not only see at the Mills county locality that the scratches upon one and the same surface prove that two separate currents existed there during some portions of the glacial period, having a divergence of thirty-one degrees with each other, but also, only about twenty miles to the northward, we find the evidence that another current moved in a direction which formed an angle of ninety-three degrees with one of those in Mills county.

Since we see no evidence of the cotemporaneous existence of obstructions which might have deflected the current of a regular southerly moving glacier, and thus have produced the scratches

in the various directions shown, it seems necessary that we should seek for some other explanation of them. Observations thus far made certainly afford very inadequate data upon which to base a definite theory concerning the real direction of glacial currents over this part of the continent, but the coincidence of the direction of those scratches which have been observed with the general course of the drainage of the region in which they occur, is worthy of careful consideration. By reference to the mention of the locality, near Burlington, at the commencement of this article, and to a map of Iowa, it will be seen that the direction of the scratches observed there, coincides pretty nearly with the general direction of the drainage of the eastern watershed of the state.

That the close of the drift period left the surface of our state unmarked by strong features, and with shallow, longitudinal depressions which gave initial direction to the courses of the streams, and that these subsequently cut out their own valleys by erosion, there seems to be no reason to doubt. It seems not improbable, also, that these initial depressions in the surface, whether primarily caused by flexures of the earth's crust, as Whitney has suggested, or not, may be regarded to some extent as indices of the general direction of ancient glacial currents.

There is another interesting matter in connection with these observations of drift phenomena along the Missouri river, and the existence of the important lacustrine deposit there. The close of the Drift period evidently left a large depression of the general surface in the region, a portion of which is now occupied in part by the counties of Fremont, Mills, Pottawatomie, Harrison and Monona. This depression became a large fresh-water lake, the borders of which have not yet been definitely ascertained, but no satisfactory evidence of its existence eastward of the East Nishnabotany river has been observed in Iowa. The Missouri river evidently emptied into this lake, and flowed from it, until it became filled with the peculiar deposit of fine, siliceous, marly material, known as the Bluff formation, the character of which is very much the same as that of the muddy material which would now be deposited from the waters of the river if it were possible to throw a permanent obstruction across it. As the valley of the river was gradually deepened during the Terrace epoch, its waters found no difficulty in sweeping out the fine homogeneous material which they had before deposited, leaving those high peculiar bluffs upon each side of its broad bottom. Fresh-water and land shells of existing species, principally Gasteropods, are often found in this deposit, from base to top, and its thickness sometimes reaches more than two hundred feet above the drift material upon which it rests.

Seventy or eighty miles to the eastward of the Missouri river,

in the southern tier of counties, there are evidences that the drift deposit reaches a thickness of more than a hundred and fifty feet. Westward from that region a sensible diminution of its thickness is seen, and, reaching the region of the Bluff formation along the Missouri river, the drift material is found in all cases comparatively thin, being thinnest where the bluff material is thickest.

At the localities where the scratches were observed, the drift material showed evidences of unusual violence of glacial action, being, as before remarked, only a few feet in thickness; and in some places in the same neighborhood it was entirely wanting, the bluff material resting directly upon the Coal-measure limestone.

An explanation of these facts is naturally sought for. The most plausible seems to be, that glacial action extended more deeply beneath the general surface here than elsewhere, and that the direction and character of the currents were such that the greater part of the drift material was swept away to other places, leaving the lake basin to be filled with water at the close of the glacial period. Further investigations, however, are needed to decide such questions as these.

It is understood that the most reliable information we can obtain in relation to the general direction of ancient glacial currents will be the identification of the transported materials with those at the places of their origin. Very few observations of this kind have yet been attempted in Iowa, and it is but fair to state that those few are not now seen to harmonize clearly with the directions of the glacial scratches just described. I refer to the reputed discoveries of galena and native copper in several of the counties upon the eastern watershed of the state. The only *known* localities from which such materials might have been derived lie to the northeastward, in a direction nearly at right angles with the eastern drainage lines. Again, profusely scattered over the region between the Missouri river and the middle of the state, as far northward as the fourth tier of counties and probably much farther, are boulders and fragments of reddish colored quartzite, closely answering the description given by Dr. Hayden of the rock which encloses the pipestone of southwestern Minnesota, and suspected to be of the same origin.* Should this be the case, it is not easy to see how they could have reached their present locations with glacial currents in the direction of the drainage of the western watershed, particularly if they are of the age to which Dr. Hayden has referred the rocks of that famous locality; for in that case they cannot be presumed to have ever existed much farther to the eastward.

* See F. V. Hayden on the Geology of Northeastern Dakota; this Journal, January, 1867.

The quartzite boulders in the region referred to are promiscuously intermixed with those of other metamorphic and of granitic origin, but those of the red quartzite are everywhere a little less waterworn and more angular than the others, suggesting a less distance of transportation, which would really be the case if derived from the pipestone region.

Iowa City, Iowa, Feb. 14th, 1867.

ART. XXXIII.—*On the General Metallurgical method of Messrs. Whelpley and Storer;* by T. STERRY HUNT, F.R.S.

THE processes having reference to the working of metallic ores, designed and introduced by Dr. James D. Whelpley and Col. Jacob J. Storer of Boston, offer numerous points of interest both mechanical and chemical, which it is proposed to notice briefly in the present paper.

1. The first step in the treatment of ores is their sub-division, which is effected by two novel and ingenious machines, called respectively the breaker and pulverizer. The first of these consists of a horizontal circular table of heavy iron, forty-two inches in diameter, revolving about one thousand times in a minute, having bolted to its upper surface four or more radial bars or blocks of chilled iron, and surrounded by a fixed upright perforated screen. The ore in fragments not more than six inches in diameter, falling into this aperture, is broken by the revolving bars into dust and small grains which are ejected through the perforated screen or curb, from which the larger particles are thrown back to complete the breaking. Such a machine with fifteen horse-power will break to the size of sand and coarse gravel eighteen or twenty tons of quartz or hard ore per hour.

The pulverizer is properly designated as an air-mill, and consists of a horizontal shaft, furnished with arms or paddles, which are made to revolve from one to three thousand times a minute, within an inch of the inner surface of a steel-lined cylinder varying from eighteen to forty inches in diameter. The previously crushed ore is introduced through an opening in the center of a plate, which covers one end of the cylinder, and is perforated with numerous small holes. The other end is connected through a diaphragm having an axial opening, with an ordinary fan-blower generally attached to the same shaft that carries the paddles. The mutual attrition of the particles of ore at the rapid rate of revolution communicated to them in the peripheral space of the mill, reduces them to fine dust, which as soon as formed is removed from the cylinder by the current of air drawn

by the fan through the perforated end, and blown into large chambers, where it is deposited. While the interaction of their particles in the mill rapidly pulverizes brittle bodies, malleable metals, in the same conditions, are soon beaten into rounded pellets. It is proposed to apply this principle to the treatment of the native copper of Lake Superior, which may then be readily separated from its earthy gangue reduced to dust by the pulverizer. This air-mill has been employed for the pulverization of various drugs, of coal, for use as a combustible in the manner about to be described, and even for the grinding of cereals, for all of which purposes it may be adapted. It has also been employed, on a large scale, to pulverize bones for use as a fertilizer. One of these air-mills forty-two inches in diameter, and moved by fifteen horse-power will reduce from 2,000 to 3,000 pounds per hour of quartz, or hard ores, to a powder many times finer than can be obtained by the use of stamps.

2. The calcination of the pulverized ores is effected in what Messrs. Whelpley and Storer call the Water-furnace. This consists of a fire-tower, from twenty to thirty feet high, built of brick, with double walls, and somewhat conical in form, being from three to four feet in diameter at the top, and from four to six at the bottom. Around its upper part are built four fire-boxes, opening into the tower near its summit, which is closed and connected with a large fan-blower. By means of this, besides an abundant supply of air, more or less heated by passing between the two walls of the tower, ore and fuel, in the state of dust, are carried downward into the furnace. The effects obtained by the combustion of charcoal or other fuel pulverized and borne in a current of hot air, are very surprising. The finely divided combustible, being kindled by the flame drawn from the fire-boxes, burns in the descending current with great energy, and from the comparatively large surface exposed to the action of the air, generates a great amount of heat, and, with an excess of fuel, an intense light. The great fiery blast, nearly filling the tower, can at pleasure be made oxydizing or reducing in its action, by regulating the supplies of fuel and of air. I have seen it, at twelve feet from the top, so potent as to heat rapidly to whiteness two feet of a wrought iron bar an inch in diameter, and cause it, though supported at both ends, to bend like wax beneath its own weight in thirty seconds after it was placed in the blast. The powerful heating effects which may be obtained by this use of pulverized fuel are readily understood when we consider that a cubic inch of coal, reduced to particles one five-hundredth of an inch in diameter, will present to the action of the atmospheric oxygen a surface equal to not less than twenty-one square feet. This application of fuel promises to have important results for heating reverberatory, muffle

and glass furnaces, for the working of iron, and even for the generation of steam. Solid combustibles are by this method practically volatilized, and broken and refuse fuel is made available.

The calcination of sulphuretted ores, however, requires but a comparatively low temperature, and an abundant supply of oxygen. The fire-tower of the water-furnace, being heated to redness, the ore, with or without addition of pulverized fuel, is driven by a small fan into the great current of air down the tower; the sulphur and the base metals are rapidly oxydized and the calcined material falls into the water-tank beneath, while the current of air passes through successive chambers, built over this tank, and open to it beneath. This movement is aided by a large fan-wheel placed at the end of the series, which being furnished with paddles dipping into the water, produces in the final chamber a great amount of spray, serving alike to precipitate the suspended dust, and promote the absorption of the sulphurous acid gas. The escape of the excess of this into the air, provided it is not required for farther use, is prevented by a second spray-wheel beyond, supplied with milk of lime or some other absorbent.

In the case of sulphuretted ores of copper, the water tank is filled with a solution of the chlorids of sodium and calcium, by which, with the aid of the spray-wheel, the sulphurous acid is absorbed, and the oxyd of copper converted into dichlorid. This beautiful process, devised by Messrs. Whelpley and Storer, I have submitted to examination, and have found that the reaction taking place may be represented as involving one equivalent of chlorid of calcium, one of sulphurous acid, and two of cupric oxyd, and giving rise to one equivalent of sulphate of lime, and one of dichlorid of copper,

$$CaCl+SO_2+Cu_2O_2=SCaO_4+Cu_2Cl.$$

A solution of chlorid of calcium holding oxyd of copper in suspension, rapidly absorbs sulphurous acid gas, and if sufficiently concentrated, is converted into a white crystalline magma of gypsum and dichlorid of copper. This latter salt I find to be soluble in a boiling hot solution of chlorid of calcium, which, however, again deposits it on cooling, a reaction which may probably be found available on a large scale in separating copper from some other metals. In ordinary cases, however, the precipitation of the dichlorid of copper in the furnace-tank is prevented by the presence in the bath of chlorid of sodium, in which, as is well known, the cuprous chlorid is readily soluble.

The calcined and oxydized ore falling into the tank which extends sixty feet or more beneath the furnace and its chambers, is carried forward, with constant agitation, by means of a sub-

merged rotating helix, and at length falls into a well at the extremity, from which it is withdrawn, freed from oxyd of copper, but generally containing a small residuum of unoxydized sulphid, which, if of sufficient importance, is separated by a repetition of the process with the Water-furnace, or by a rapid calcination in a reverberatory, of the mass impregnated with chlorids, by which means the residual copper left by imperfect burning becomes readily soluble in the sulphurous chlorid bath of the water-tank.

A small but variable proportion of protochlorid of iron generally accompanies the chlorid of copper, and may be separated from the cuprous solution by a simple reaction which I also studied. Three equivalents of cupric oxyd, and two of ferrous chlorid, yield by their reaction one equivalent each of cuprous and cupric chlorids, and one of sesquioxyd of iron,

$$Cu_3O_3+Fe_2Cl_2=Cu_2Cl+CuCl+Fe_2O_3.$$

The addition to the heated solution, separated from gypsum and insoluble matters, of a portion of cupric oxyd therefore suffices to precipitate the whole of the dissolved iron, and the dinoxyd of copper in the presence of air rapidly produces a similar result. The addition of milk of lime now throws down, from the solution of cuprous chlorid, the whole of the copper as pure hydrous dinoxyd, whose subsequent reduction to the metallic state is a very simple operation. Meanwhile the chlorid of calcium is regenerated, and the bath restored to its original condition may thus be used an indefinite number of times, the only reagent consumed in the process, in addition to the elements of the ore, and the oxygen of the air, being the equivalent of lime used to precipitate cuprous oxyd.

It will be seen that for sulphuretted ores containing gold, the treatment in the fire-tower, with the aid of a bath of water only, affords a simple mode of desulphurization, and leaves the gold particles in a state most favorable for amalgamation, while in the case of auriferous ores containing copper, a similar result may be obtained, and the copper, which is lost in the ordinary method of working such ores, recovered by means of the chlorid bath.

It is claimed by the designers of this series of processes, that copper can in this way be produced, at about one-third the cost of the ordinary method. The small consumption of fuel, and the mechanical facilities afforded for handling great masses of material, are such, that the new method will probably be found especially advantageous, in the treatment of low grade ores, in regions where transportation is difficult, and fuel scarce. The patentees have a small experimental furnace eighteen feet high, at East Boston, but are now erecting at the Harvey Hill mine,

near Quebec, a furnace thirty feet high, which, it is expected, will enable them to treat fifty tons of seven per cent ore in twenty-four hours.

The application of the Water-furnace to the treatment of the sulphuretted ores of other metals, presents many points of interest, whose consideration is reserved for another time.

Montreal, Feb. 21, 1867.

ART. XXXIV.—*The Repsold Portable Vertical Circle;* by CLEVELAND ABBE.

(Continued from page 216.)

As to the methods and formulæ used in connection with the vertical circle, it is evident that we need first some means of orientation on arriving at a new station. An observation of any terrestrial object will give an approximate knowledge of the zenith point, and an approximate value of the latitude is easily had from a map or by estimation. With one pointing upon any recognizable celestial object, we have then its azimuth and zenith distance for a given observed moment, whence the following computation gives us the approximate north point of the azimuth circle and the hour angle.

Put $90°-\delta=a$ $\quad s-a=\alpha$ $\quad \varkappa=\sqrt{\frac{\sin\alpha\sin\beta\sin\gamma}{\sin s}}$

$90°-\varphi=b$ $\quad s-b=\beta$

$z=c$ $\quad s-c=\gamma$ $\quad \Sigma=\frac{\varkappa}{\sin s}$

$2s=a+b+c$ $\quad 2s=\alpha+\beta+\gamma$

The Gaussian formulæ give for the azimuth, parallactic angle and hour angle,

(B.) $\tan\frac{1}{2}A=\frac{\varkappa}{\sin\alpha}$ $\quad \tan\frac{1}{2}p=\frac{\varkappa}{\sin\beta}$ $\quad \tan\frac{1}{2}t=\frac{\varkappa}{\sin\gamma}$

$$\tan\tfrac{1}{2}A\,\tan\tfrac{1}{2}p\,\tan\tfrac{1}{2}t=\Sigma.$$

The computation with its controls is of course performed with 4-figure logarithms. The observed azimuth, plus or minus the computed A, gives the north point of the circle. The computed t, plus the tabular R.A., gives the sidereal time, whence is found the clock correction.

A previously computed ephemeris of the stars to be observed enables us now to point upon any one. Polaris will naturally be first chosen, as by it we may more accurately determine the north point or adjust the azimuth circle to N.P.=0°, as is most convenient if any number of observations is to be made.

An ephemeris of the azimuths and zenith distances of the principal stars, if computed for every 5° of latitude, will serve by interpolation for any intermediate position. The formulæ for the computation of finding ephemerides as given by Mr. Döllen are very simple.

Put $z-(\varphi-\delta)=r$; the well known formula,

$$\cos z=\cos(\varphi-\delta)-2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

gives

$$\text{(C.)}\qquad \sin\tfrac{1}{2}r=\cos\varphi\sin^2\tfrac{1}{2}t\frac{\cos\delta}{\sin(\varphi-\delta+\frac{1}{2}r)}.$$

Another well known formula may be written

$$\text{(D.)}\qquad \sin A=\sin t\frac{\cos\delta}{\sin(\varphi-\delta+r)}.$$

Or by a transformation of

$$\sin z\cos A=-\cos\varphi\sin\delta+\sin\varphi\cos\delta\cos t,$$

these results, approximately,

$$\text{(D'.)}\qquad \sin^2\tfrac{1}{2}A=\sin\varphi\sin^2\tfrac{1}{2}t\frac{\cos\delta}{\sin(\varphi-\delta)}.$$

Neglecting the r in the second members of these equations, they admit of a very simple arrangement for the computation of an ephemeris whose argument is the time for stars near the meridian, being sufficiently accurate within the limits

$$\varphi-\delta>10^\circ \text{ and } t<15^\circ.$$

For an ephemeris in the neighborhood of the prime vertical we may use the azimuth as argument; counting it from the west point northward, we have

$$\text{(E.)}\qquad \sin\delta=\sin\varphi\cos z+\cos\varphi\sin z\sin A$$

$$\text{(F.)}\qquad \tan\delta=\frac{1}{\cos\varphi}\sin t\tan A+\tan\varphi\cos t.$$

Put $$\tan\zeta=\frac{\sin A}{\tan\varphi} \text{ and } p=\frac{\cos\zeta}{\sin\varphi};$$

the first formula (E) becomes

$$\text{(G.)}\qquad \cos z'=\cos(z-\zeta)=p\sin\delta;$$

whence $$z=z'\pm\zeta.$$

Put $$\tan\omega=\frac{\tan A}{\sin\varphi} \text{ and } q=\frac{\cos\omega}{\tan\varphi};$$

the second formula (F) becomes

$$\text{(H.)}\qquad \cos t'=\cos(t-\omega)=q\tan\delta;$$

whence $$t=t'\pm\omega.$$

The arrangement of these computations can be made exceedingly convenient. Extensive ephemerides for latitude 35° to 70° north have been published by General Tenner; provided with

these or similar special ones the observer loses no time in selecting the pair of stars to be observed. The latitude stars are of course observed on the meridian as nearly as possible, excepting the polars, which are observed at any hour angle.

In the accurate computation of the results, the following formulæ are used by Mr. Döllen, following Struve's habit of separately reducing each observation.

a. For the polars, all observed zenith distances are reduced to the upper culmination. The formula (C) may be written

$$\text{(I.)} \qquad \sin\tfrac{1}{2}(z-\zeta)=\cos\varphi\cos\delta\,\frac{\sin^2\tfrac{1}{2}t}{\sin\tfrac{1}{2}(z+\zeta)},$$

or approximately

$$\text{(J.)} \qquad r=z-\zeta=\frac{2\cos\varphi\cos\delta}{\sin 1''}\cdot\frac{1}{\sin\tfrac{1}{2}(z+\zeta)}\cdot\sin^2\tfrac{1}{2}t,$$

where $$\zeta=\varphi-\delta.$$

Provided with the Wrangell or other convenient extended tables of $\sin^2\frac{1}{2}t$, and assuming an approximate φ and zenith point and using the value of $z+\zeta$ for the middle of the series as a constant throughout the whole, we easily compute the individual values of r whence result the circle readings for each observation as if it had been made at the upper culmination. The mean of the four observations circle right and the four circle left gives the correct zenith point, the zenith distance ζ and the approximate latitude. With these a second approximation is made, and more will not generally be required. In the second approximation the new refractions and $\sin\frac{1}{2}(z+\zeta)=\sin(\varphi-\delta+\frac{1}{2}r)$ need not be anew computed, since the first differences of the logarithmic tables will give the $\Delta\log r$ corresponding to the $\Delta\varphi$ and Δz.

If the zenith point and latitude are sufficiently well known, it will be equally expeditious to compute the direct formula

$$\cos\zeta=\cos z+2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

using of course convenient tables for $\sin^2\frac{1}{2}t$ and Zech's tables for addition.

b. For other stars than the polars observed near the meridian, the direct computation of $\log r$ by means of the following series will be found convenient. We have from (C)

$$\text{(K.)} \qquad \sin r+2\sin^2\tfrac{1}{2}r\cot\zeta=2\frac{\cos\varphi}{\sin\zeta}\cos\delta\,\sin^2\tfrac{1}{2}t;$$

whence

$$\text{(L.)} \qquad r+\frac{r^2}{2}\cot\zeta\sin 1''-\frac{1}{6}r^3\sin^2 1'',\ \&c.=2\frac{\cos\varphi\cos\delta}{\sin\zeta\sin 1''}\sin^2\frac{t}{2}.$$

Regarding the second member as a first approximation to r, and developing the $\sin^2\frac{1}{2}t$, we obtain the following, which is due to Mr. Döllen,

$$\text{(M.)} \qquad \log r=\log(pt^2)-qt^2;$$

in which we have put

$$g=\text{hourly gain on sidereal time}, \qquad f=\frac{3600^s}{3600+g},$$

$$\beta=3\frac{\cos\varphi\cos\delta}{\sin\zeta}, \qquad \gamma=\cot\zeta,$$

$$p=\frac{37{\cdot}5}{R}f^2\beta=[6{\cdot}25961]f^2\beta,$$

$$q=\frac{\text{Mod}}{2R}p(\tfrac{1}{\beta}\pm\gamma)=[9{\cdot}0223]p(\tfrac{1}{\beta}\pm\gamma).$$

c. For the computation of the hour angle from the observed zenith distances in the prime vertical, we have the simple formula

$$\text{(N.)} \qquad \sin^2\tfrac{1}{2}t=\frac{\cos\zeta}{2\cos\varphi\cos\delta}\left(1-\frac{1}{\frac{\cos\zeta}{\cos z}}\right);$$

the computation of which is sufficiently expeditious even with six-figure logarithms, if we are provided with the tables previously mentioned. The second approximation, using a correct zenith point, is made if necessary as before, by using the tabular first differences.

As the formula (A) shows, the flexure of the tube to be not symmetrical with respect to the zenith, it is necessary for greater accuracy to correct the results given by each star of a pair, according to the formula

$$f=b\sin(z+\text{B}).$$

The correction, f, is directly applicable to the zenith distances observed for latitude.

For the time determination we have the differential formula

$$\text{(P.)} \qquad dt^s=-\frac{\sin z}{15\cos\varphi\cos\delta\sin t}\,dz''.$$

The application of these corrections is, especially for the latitude, necessary in order to entirely free the result from a pair of opposite stars from the influence of flexure.

To the preceding sketch of the instrument and its formulæ may be added a few words as to the conduct of the field work, which may be carried on without inconvenience at a temperature of 15° or 20° Fahrenheit.

In the Russian empire, where railroads do not offer sufficient accommodation to the geodesist, it is necessary that an expedition should be provided with an easy spring-van drawn by two or three horses (the Russian officer is only perfectly happy when rushing along with his *troika*). In this covered wagon the twelve or fifteen chronometers are as well as possible protected against rapid changes of temperature and disturbing jars. One or two barometers with thermometers are provided; the barometers of Brauer's construction have been found to endure surpris-

ingly well the rough usage to which they must needs be subjected in journeys of thousands of miles. A heavy tripod is provided, and the means for leaving a suitable simple mark at any station. The vertical circle, without being in the least taken to pieces, is received as a whole into its small neat case in which two clamps firmly fasten it, an outer thick leather cover with handles protects the whole, which is carried with ease by two men, or by one if need be, as it scarcely weighs sixty pounds. The entire load occupies a space of some twenty cubic feet.

Arrived at the previously reconnoitred station, five or ten minutes suffice for the two attendants to erect the tripod and set the vertical circle upon it; sometimes a block of stone or three stakes of wood support the feet of the tripod and remain to mark the station. Meantime the horses having been unhitched and the barometer and thermometers hung up, the chronometers (including the extremely under- or over-compensated ones) are, by means of the one beating 13 times in 6 seconds, very rapidly compared with the one to be used in the observations. The examination of the state of the instrument and the adjustment of the verticality of the vertical axis follow, and in a few minutes after observing the Sun or Moon, Polaris is in the field of view. Although one determination only of time is necessary, it is better to make two, arranging the work as follows:

1. Comparison of chronometer.
2. Reading of barometer and thermometer.
3. Observation of pair of stars for time.
4. Reading of barometer and thermometer.
5. Observation of pair of stars for latitude.
6. Reading of barometer and thermometer.
7. Observation of pair of stars for time.
8. Reading of barometer and thermometer.
9. Comparison of chronometer.

The observations are now complete and the party may proceed to the next station; if any considerable time elapses the departure should be immediately preceded by another comparison of chronometers.

The time spent at any station must depend upon the skill, energy and self-devotion of the observer. In the expedition by Döllen and Hübner in 1855–56 in the province of Perm, cases occur where three stations, distant twenty-five to forty miles from each other, have been thus occupied within the space of thirty-six hours, the time spent at each being about three hours, the intervening distances being travelled over very ordinary roads. It is often very advisable to work expeditiously in order to improve a few days of consecutive clear weather and secure a quick return to the starting point, without having exposed the chronometers to a long absence or dangerous temperature changes. This latter point is one requiring especial and intelli-

gent watchfulness on the part of the observer. Captain Bolscheff, having charge of the determination of some two hundred points in Finnland, mentioned to me the difficulties that he had to contend with arising from the sudden fall in the atmospheric temperature during the night, obliging him sometimes to stop while proceeding from one station to another, not only to make extra comparisons of his chronometers, but by artificial warmth to endeavor to counteract the influence of the rapid fall in the exterior temperature.

Without here farther entering into the details of the methods pursued by Colonel Smyssloff in obtaining the final corrections for the rates of his chronometers and the longitudes of his stations relative to Poulkova, we will note that the twenty stations here given cover an area of some 135 miles square in the provinces of Novgorod and St. Petersburg, and the expeditions occupied him from the 18th of June to the 31st of July, 1859. Two journeys were undertaken, the first leaving Poulkova June 18th, visited stations I, 2, II, 2, III, 3, 4, 5, 6, I, returning to Poulkova July 3d. The second left Poulkova July 5th, and visited IV, VI, 7, 8, 9, IV, arriving at Nova Ladoga the 13th of July; the same day leaving Nova Lagoda, and visiting 10, IV, 9, 13, V, 14, 15, I, it returned to Poulkova July 31st. The whole distance travelled in this six weeks expedition was 1400 miles, of which 175 were by railroad. Each latitude depends upon eight pointings upon Polaris and eight upon some southern star; the probable error of each resulted in general $\pm 0''.3$. Each longitude (as to the fourteen secondary stations) depends in general upon one time determination; the probable error of each is given below. Ten chronometers were carried, besides the non-compensated one and the one beating $\frac{6}{13}$ seconds and the one used in observing. There were in all twenty-nine determinations of time and fifteen of latitude.

Station.	Latitude. Probable error $\pm 0''.3$.	Longitude from Poulkova.	Prob. error. $\pm$
	° ′ ″	m. s.	s.
1. Spasska Orlayno,	59 15 53·8	− 0 53·43	0·08
2. Kamenni Polarne,	58 48 39·8	+ 1 28·34	0·07
3. Arm Spasska Poleust,	58 55 15·7	+ 4 44·91	0·09
4. Korovay Roustchay,	59 13 24·8	+ 3 25·33	0·08
5. Samost,	59 29 31·8	+ 3 46·20	0·09
6. Uspensko,	59 41 45·9	+ 3 9·00	0·10
7. Rougoi,	59 28 13·8	+10 7·61	0·12
8. Oskoua,	59 16 43·5	+ 7 2·95	0·12
9. Podzopie,	59 38 43·6	+ 7 10·61	0·10
10. Schassenske,	60 3 28·2	+12 34·52	0·10
11. Taykvayn,	59 38 48·5	+12 44·35	0·08
12. Podsosno,	59 14 32·2	+12 52·73	0·10
13. Krayvar Gora,	59 3 8·1	+11 7·87	0·09
14. Morkonnayzi,	58 50 24·0	+10 29·38	0·09
15. Malar Veschera,	58 50 51·0	+ 7 33·91	0·08
16. Nova Ladoga,	60 6 40·3	+ 7 58·78	0·05

As fundamental points of reference for the longitudes the following list was selected of points determined in previous years.

Station.	Latitude.	Longitude.
I. Poulkova,	59° 46′	0h 0m 0s
II. Louga,	58 43	−0 1 54·20
III. Novgorod,	58 30	+0 3 47·86
IV. Nova Ladoga,	60 7	+0 7 58·80
V. Borovaytsche,	58 24	+0 14 19·93
VI. Taykvayn,	59 39	+0 12 44

Of these, however, it was preferred to include IV and VI among those to be independently determined on the present occasion, and they have received the numbers 16 and 11 in the previous list.

Among several similar expeditions that have come to my notice, I may mention those before referred to, of Messrs. Döllen and Hübner in 1855–56 in the government of Perm, where many points have been unusually carefully determined with reference to Perm and Ekaterineberg; and that of Captain Bolscheff in Finnland in 1863–66, each of whose 150 points has been twice independently determined.

An extensive series of observations made at Poulkova with a vertical circle, made in 1857 by Messrs. Repsold, still farther attests, if any farther proof were wanted of the reliability of the results afforded by this instrument—to observe with which is in fact a luxury of convenience. The observations made on distant terrestrial signals—the reflection from gilded church domes—gave for perfect condition of images the probable accidental error of a zenith distance resulting from two pointings in opposite positions of the circle $\pm 0''\cdot 52$, a large portion of which may fall upon the level, which was afterwards improved by the addition of a narrow mirror reflecting the divisions horizontally to the observer's eye.

A suggestion of Mr. Döllen as to the interest that would attach to a comparison of the results obtained by the vertical circle with those obtained by using the Talcott zenith telescope —and the suggestion that by clamping the vertical circle and observing stars of exactly equal zenith distances, thus freeing the results from errors arising from imperfect graduation of the circle, by converting the vertical circle into a very convenient zenith telescope—both seem to be well worthy of being put into execution. In the determination of time I have been able to apply this latter method of using the vertical circle: it remains to attempt the same in the determination of latitude.

37 East 20th st., New York, January, 1867.

ART. XXXV.—*On the Reduction of Meteorological Observations;* by ERASTUS L. DEFOREST.

THE system of twelve equations for correcting monthly means for the unequal length of the months, given by me in this Journal, vol. xlii, page 155, was obtained on the supposition that the year consists of 365¼ days. The true length of the year being a very little less than this, it follows that the equations referred to are not exactly correct. The amount of inaccuracy in their results is indeed very small, but still it seems desirable that fundamental formulas of this kind should not involve any unnecessary errors, however small they may be. The equations can be computed just as well by giving the year its true length, care being taken to assign the true values to the arcs n_1, n_2, n_3, and c, which measure the lengths of the months, and also to the small arc x_1, which measures the time from the middle of a calendar month to the middle of the corresponding mean month.

On the assumption that the year contains 365·24224 days, a mean month will contain 30·43685 days, and the calendar month of February 28·24224 days. A month of 31 days will be represented by the arc 30° 33′ 18″·2, a month of 30 days by 29° 34′ 9″·9, and the month of February by 27° 50′ 12″·8. The values of x_1 for the several months are therefore

January,	−0°	16′	39″·1	July,	1° 4′ 53″·6
February,	+0	31	35 ·4	August,	0 31 35 ·4
March,	1	19	49 ·9	September,	0 27 51 ·3
April,	1	16	5 ·8	October,	0 24 7 ·3
May,	1	12	21 ·7	November,	0 20 23 ·2
June,	1	8	37 ·7	December,	0 16 39 ·1

and the twelve equations are found to be

$$\begin{aligned}
M_1 &= m_1 + {\cdot}0037\, m_1 + {\cdot}0030\, m_{12} - {\cdot}0067\, m_2 \\
M_2 &= m_2 - {\cdot}0127\, m_2 - {\cdot}0031\, m_1 + {\cdot}0158\, m_3 \\
M_3 &= m_3 + {\cdot}0028\, m_3 - {\cdot}0249\, m_2 + {\cdot}0221\, m_4 \\
M_4 &= m_4 - {\cdot}0042\, m_4 - {\cdot}0200\, m_3 + {\cdot}0242\, m_5 \\
M_5 &= m_5 + {\cdot}0016\, m_5 - {\cdot}0218\, m_4 + {\cdot}0202\, m_6 \\
M_6 &= m_6 - {\cdot}0039\, m_6 - {\cdot}0180\, m_5 + {\cdot}0219\, m_7 \\
M_7 &= m_7 + {\cdot}0026\, m_7 - {\cdot}0200\, m_6 + {\cdot}0174\, m_8 \\
M_8 &= m_8 + {\cdot}0025\, m_8 - {\cdot}0103\, m_7 + {\cdot}0078\, m_9 \\
M_9 &= m_9 - {\cdot}0027\, m_9 - {\cdot}0067\, m_8 + {\cdot}0094\, m_{10} \\
M_{10} &= m_{10} + {\cdot}0030\, m_{10} - {\cdot}0085\, m_9 + {\cdot}0055\, m_{11} \\
M_{11} &= m_{11} - {\cdot}0026\, m_{11} - {\cdot}0046\, m_{10} + {\cdot}0072\, m_{12} \\
M_{12} &= m_{12} + {\cdot}0032\, m_{12} - {\cdot}0064\, m_{11} + {\cdot}0032\, m_1
\end{aligned}$$

It will be seen that the numerical coëfficients here given differ from the previous ones to the amount, in some cases, of a single unit in the fourth decimal place. They are, I believe, as nearly exact as they can be made without extending them beyond the

fourth place, a degree of refinement which would be practically useless. The computation, however, was carefully made to six places, so as to secure the nearest value for the last figure. In rejecting the fifth and sixth places, care has been taken not to impair the condition that in any single equation the sum of the three decimal coëfficients must be zero. The first and seventh equations, as computed to six places, are

$$M_1 = m_1 + \cdot 003668\, m_1 + \cdot 003060\, m_{12} - \cdot 006728\, m_2$$
$$M_7 = m_7 + \cdot 002541\, m_7 - \cdot 019981\, m_6 + \cdot 017440\, m_8.$$

When these are reduced to four places in the usual way, they become

$$M_1 = m_1 + \cdot 0037\, m_1 + \cdot 0031\, m_{12} - \cdot 0067\, m_2$$
$$M_7 = m_7 + \cdot 0025\, m_7 - \cdot 0200\, m_6 + \cdot 0174\, m_8.$$

The sums of the three decimal coëfficients differ from zero to the amount of a single unit in the fourth place; and to correct this, the unit has been added to or subtracted from that coëfficient which is least altered by it, as compared with its true value to six places.

Since the length of a calendar year is either 365 or 366 days, the assumption that the year consists of 365·24224 days is not strictly applicable to meteorological observations for any single year. But the average length of a considerable number of consecutive calendar years approaches very closely to that of the true or astronomical year, and the greater the number of years the closer will be the approximation. Therefore when we are considering the mean results of observations which have extended over a long course of years, the assumption that calendar years and astronomical years are equal will lead to no error. In the same way we are justified in assigning 28·24224 days to February, because this is the average length of that month for a series of many consecutive years.

When the equation of the curve representing the annual course of any meteorological phenomenon, as the mean daily temperature for instance, has been found for a given place by the method of mean months, and it is required to interpolate from it the mean temperature of a particular day, care should be taken to assign the proper value to the abscissa. Take for example the 15th day of March. The time elapsed from the beginning of the year to the middle of that day is $31+28\cdot2422+14\frac{1}{2}=73\cdot7422$ days, and the corresponding arc is found by the proportion

$$365\cdot2422 \text{ days} : 73\cdot7422 \text{ days} = 360^\circ : 72^\circ\ 41'.$$

The value 72° 41′ being given to the abscissa in the equation of the curve, the resulting value of the ordinate will be the mean daily temperature at the given place on the 15th of March. The abscissa must be reckoned up to the middle of the day, be-

cause the small arc of the curve which belongs to any one day may be regarded as approximately a straight line, so that the mean of all its ordinates is equal to its middle ordinate, which therefore represents the mean temperature of the day. The subjoined table will be found to facilitate computations. It gives the abscissa for the middle point of each day in the year, correct to the nearest minute, one minute of arc here corresponding to about twenty-four minutes of time.

Arcs representing the mean interval of time from the beginning of the year to the middle of each day.

	Jan.	Feb.	M'ch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	0 30	31 3	58 53	89 26	119 1	149 34	179 8	209 41	240 15	269 49	300 22	329 56
2	1 29	32 2	59 52	90 26	120 0	150 33	180 7	210 40	241 14	270 48	301 21	330 55
3	2 28	33 1	60 51	91 25	120 59	151 32	181 6	211 40	242 13	271 47	302 20	331 55
4	3 27	34 0	61 51	92 24	121 58	152 31	182 5	212 39	243 12	272 46	303 20	332 54
5	4 26	34 59	62 50	93 23	122 57	153 30	183 5	213 38	244 11	273 45	304 19	333 53
6	5 25	35 59	63 49	94 22	123 56	154 30	184 4	214 37	245 10	274 44	305 18	334 52
7	6 24	36 58	64 48	95 21	124 55	155 29	185 3	215 36	246 9	275 44	306 17	335 51
8	7 24	37 57	65 47	96 20	125 55	156 28	186 2	216 35	247 9	276 43	307 16	336 50
9	8 23	38 56	66 46	97 19	126 54	157 27	187 1	217 34	248 8	277 42	308 15	337 49
10	9 22	39 55	67 45	98 19	127 53	158 26	188 0	218 34	249 7	278 41	309 14	338 49
11	10 21	40 54	68 44	99 18	128 52	159 25	188 59	219 33	250 6	279 40	310 13	339 48
12	11 20	41 53	69 44	100 17	129 51	160 24	189 59	220 32	251 5	280 39	311 13	340 47
13	12 19	42 53	70 43	101 16	130 50	161 24	190 58	221 31	252 4	281 38	312 12	341 46
14	13 18	43 52	71 42	102 15	131 49	162 23	191 57	222 30	253 3	282 38	313 11	342 45
15	14 18	44 51	72 41	103 14	132 48	163 22	192 56	223 29	254 3	283 37	314 10	343 44
16	15 17	45 50	73 40	104 13	133 48	164 21	193 55	224 28	255 2	284 36	315 9	344 43
17	16 16	46 49	74 39	105 13	134 47	165 20	194 54	225 28	256 1	285 35	316 8	345 42
18	17 15	47 48	75 38	106 12	135 46	166 19	195 53	226 27	257 0	286 34	317 7	346 42
19	18 14	48 47	76 38	107 11	136 45	167 18	196 53	227 26	257 59	287 33	318 7	347 41
20	19 13	49 47	77 37	108 10	137 44	168 17	197 52	228 25	258 58	288 32	319 6	348 40
21	20 12	50 46	78 36	109 9	138 43	169 17	198 51	229 24	259 57	289 32	320 5	349 39
22	21 11	51 45	79 35	110 8	139 42	170 16	199 50	230 23	260 57	290 31	321 4	350 38
23	22 11	52 44	80 34	111 7	140 42	171 15	200 49	231 22	261 56	291 30	322 3	351 37
24	23 10	53 43	81 33	112 7	141 41	172 14	201 48	232 22	262 55	292 29	323 2	352 36
25	24 9	54 42	82 32	113 6	142 40	173 13	202 47	233 21	263 54	293 28	324 1	353 36
26	25 8	55 41	83 32	114 5	143 39	174 12	203 46	234 20	264 53	294 27	325 1	354 35
27	26 7	56 40	84 31	115 4	144 38	175 11	204 46	235 19	265 52	295 26	326 0	355 34
28	27 6	57 40	85 30	116 3	145 37	176 11	205 45	236 18	266 51	296 26	326 59	356 33
29	28 5	58 16	86 29	117 2	146 36	177 10	206 44	237 17	267 51	297 25	327 58	357 32
30	29 5		87 28	118 1	147 36	178 9	207 43	238 16	268 50	298 24	328 57	358 31
31	30 4		88 27		148 35		208 42	239 15		299 23		359 30

When the mean daily temperatures at a given place have been tabulated for every day in the year, it seems to have been the usual practice hitherto to omit giving the temperature for the 29th of February. It cannot be said that the meteorological phenomena which occur on a single intercalary day are less important, or less worthy of being observed and recorded and combined with others to form the monthly mean, than are those of any other single day. The interval of time between the mean position of the beginning of the calendar year and the mean position of the middle of the intercalary day is assignable with great precision, and when an equation of temperatures has

been found by the use of mean months, the mean temperature of the 29th day of February can be interpolated with as much accuracy as that of any other day whatever. The time elapsed from the beginning of the year to the middle of the intercalary day is $31+28+\frac{1}{2}$ of $0{\cdot}2422=59{\cdot}1211$ days, and the corresponding abscissa is found to be 58° 16′.

The monthly means of temperature at New Haven, as given in the Transactions of the Connecticut Academy of Arts and Sciences, from 86 years' observations, are

26·53	46·84	71·66	51·10
28·11	57·28	70·32	40·32
36·09	66·96	62·50	30·42

When reduced to mean months they become

26·5311	47·3076	71·7307	50·9438
28·2410	57·7031	70·2452	40·1992
36·5263	67·2372	62·3404	30·3442

From these data I have obtained the equation of mean daily temperatures throughout the year, in the way already stated in this Journal, xli, 373, except that instead of finally reducing it from the usual form,

$$y=a+a_1\sin(x+\mathrm{E}_1)+a_2\sin(2x+\mathrm{E}_2)+a_3\sin(3x+\mathrm{E}_3)+\text{ &c.},$$

into a form where the signs before the terms are sometimes plus and sometimes minus, I have reduced it to

$$y=a+a_1\sin(x-e_1)+a_2\sin 2(x-e_2)+a_3\sin 3(x-e_3)+\text{ &c.},$$

in accordance with the formula

$$\sin(nx+\mathrm{E}_n)=\sin n\left\{x-\frac{1}{n}(360°-\mathrm{E}_n)\right\}.$$

This prevents confusion of signs, and at the same time preserves the significance of the arc e_n, making it measure the time elapsed from the beginning of the year to the *first ascending node* of the term in which it occurs.

The New Haven equation of temperatures then is

$$\begin{aligned}y=49{\cdot}112&+22{\cdot}902\sin(x-110°\ 39'\ 22'')+{\cdot}289\sin 2(x-20°\ 56')\\&+{\cdot}443\sin 3(x-57°\ 42')+{\cdot}022\sin 4(x-75°\ 22')\\&+{\cdot}402\sin 5(x-3°\ 53')+{\cdot}093\sin 6x.\end{aligned}$$

An equation of this kind, to be perfect, ought to express accurately all the facts implied in the observed series of monthly means, so that the mean for any one of the calendar months may be derived from it with precision, by integrating ydx between the proper limits for the beginning and end of the month, and dividing by the arc which measures its length. Let the general form,

$$y=a+a_1\sin(x-e_1)+a_2\sin 2(x-e_2)+a_3\sin 3(x-e_3)+\text{ &c.},$$

be treated in this way between the limits x' and x'' correspond-

ing to the beginning and end of a month whose mean is m, and let us make

$$\tfrac{1}{2}(x''-x')=\alpha, \qquad \tfrac{1}{2}(x''+x')=\beta;$$

then the monthly mean will be expressed thus:

$$m=a+a_1\frac{\sin\alpha}{\alpha}\sin(\beta-e_1)+a_2\frac{\sin 2\alpha}{2\alpha}\sin 2(\beta-e_2)+a_3\frac{\sin 3\alpha}{3\alpha}\sin 3(\beta-e_3)+\text{ \&c.}$$

The values of $\frac{\sin\alpha}{\alpha}$, $\frac{\sin 2\alpha}{2\alpha}$, &c., depend only on the length of the month, and their logarithms are given in the subjoined table, for months of all the different lengths.

	Month of 31 days.	Month of 30 days.	February.	Mean months.
$\log\frac{\sin\alpha}{\alpha}$	9·994840	9·995169	9·995719	9·995027
$\log\frac{\sin 2\alpha}{2\alpha}$	9·979214	9·980547	9·982777	9·979971
$\log\frac{\sin 3\alpha}{3\alpha}$	9·952651	9·955722	9·960852	9·954395
$\log\frac{\sin 4\alpha}{4\alpha}$	9·914288	9·919945	9·929367	9·917502
$\log\frac{\sin 5\alpha}{5\alpha}$	9·862723	9·872015	9·887409	9·868005
$\log\frac{\sin 6\alpha}{6\alpha}$	9·795732	9·810048	9·833588	9·803880

The values of the arc β, which measures the time from the beginning of the year to the middle of a month, are for the calendar months

15° 16′ 39″	103° 43′ 54″	193° 55′ 6″	284° 35′ 53″
44 28 25	133 47 38	224 28 25	314 39 37
73 40 10	163 51 22	254 32 9	344 43 21

and for mean months they are 15°, 45°, 75°, &c.

Now in the expression for the monthly mean m, let the constants a, a_1, e_1, a_2, e_2, &c., take those values which have been found for them in the New Haven equation, and the following monthly means for the calendar months may be obtained.

26·530	46·870	71·668	51·093
28·111	57·278	70·313	40·324
36·056	66·949	62·512	30·424

The errors of these computed values as compared with the monthly means actually observed are

·0	+·030	+·008	−·007
+·001	−·002	−·007	+·004
−·034	−·011	+·012	+·004

This example shows the degree of accuracy with which an equation obtained by the method of mean months may be expected to represent any observed series of means for calendar

months. The reason why the computed values do not agree exactly with the observed ones is, that the curve of the form

$$y=a+a_1 \sin(x-e_1),$$

by means of which my system of twelve equations was obtained, is only an approximation to the true curve for any month, and is not the same as the computed curve whose equation contains twelve constants. The two curves approach each other closely, and intersect at several points, but they do not coincide. They both include the same monthly mean for the mean month, but not for the calendar month. It is probable, however, that no other method of reduction of equal simplicity will give an equation which expresses the means for the calendar months so accurately as this.

It should be noticed that when monthly means of rain-fall are to be corrected for the inequality of the months by my system of equations, the correction must be applied not to the mean *total* amount of rain for any month, but to the mean *daily* amount for that month. Take, for instance, the results of 24 years' observation at Albany, from 1826 to 1849 inclusive, given by F. B. Hough in the "New York Meteorology." The mean total amounts of rain and melted snow and hail for the calendar months, in inches of depth, are

2·91	2·88	4·09	3·76
2·62	4·04	3·44	3·30
3·02	4·50	3·47	2·98

Dividing each of these by the number of days in the month, we have the following values of the mean daily rain-fall, for calendar months, in decimals of an inch:

·0939	·0960	·1319	·1213
·0928	·1303	·1110	·1100
·0974	·1500	·1157	·0961

Now applying the correction, we obtain the mean daily rain-fall for mean months,

·0939	·0968	·1312	·1213
·0929	·1314	·1108	·1098
·0975	·1500	·1158	·0960

and the equation of the curve is found to be

$$\begin{aligned} y=&\cdot1123+\cdot0202\sin(x-106^\circ\ 43')+\cdot0106\sin 2(x-107^\circ\ 10') \\ &+\cdot0112\sin 3(x-14^\circ\ 11')+\cdot0031\sin 4(x-51^\circ\ 7') \\ &+\cdot0024\sin 5(x-56^\circ\ 40')+\cdot0015\sin 6x. \end{aligned}$$

If we assign to x the value appropriate for any given day in the year, the resulting value of y will be the average depth of rain-fall at Albany for that day, expressed in decimals of an inch.

After an equation has been obtained, there ought to be some

check to show whether it is free from errors of computation. This may be secured by deriving from it the mean for any one of the mean months. When the constants in the Albany equation are transferred to the general expression for the monthly mean, and α and β take the values appropriate for the third mean month for instance, the result is $m = \cdot 0975$; the agreement of this with the daily mean for the third mean month as previously found, is evidence that the equation of the curve has been computed correctly.

January 11th, 1867.

ART. XXXVI.—*Researches on Solar Physics;* by WARREN DE LA RUE, Esq., Pres. R.A.S., BALFOUR STEWART, Esq., Superintendent of the Kew Observatory, and BENJAMIN LOEWY, Esq., Observer and Computer to the Kew Observatory.

Second Series (in continuation of First Series). Area-measurement of the Sun-spots observed by Carrington during the seven years from* 1854–1860 *inclusive, and deduction therefrom.*

34. In our first paper (Art. 13) we stated that Mr. Carrington had very kindly placed at our disposal all his original drawings of sun-spots. Our first step was to arrive at some estimate of the accuracy of these sketches, and we requested Dr. von Bose, who assisted Mr. Carrington in the greater part of his observations, to give us a short outline of the method employed in obtaining them.

From his account, it would appear that the sun's disk was thrown upon a screen, and that each group as represented on the screen was separately drawn on a sheet of paper. The groups on paper were then each separately compared with those on the screen and modified where faulty; and this process was continued until the paper sketches agreed as nearly as possible with the groups on the screen. It would thus appear that very great care was taken with these sketches. [Engravings of several of Carrington's sketches alongside of those of corresponding groups as taken by the Kew Heliograph are given in the original memoir, showing that Carrington has obtained by the method above described a very great accuracy of delineation.]

35. The trustworthiness of Carrington's sun-pictures being thus established, it seemed to us that the labor of measuring for each group the amount of spotted area would be well bestowed, inasmuch as the method hitherto employed, namely, the mere statement of the number of sun-spots occurring at any pe-

* From a memoir printed for private circulation; tables and plates, and many paragraphs omitted. For First Series, see p. 179.

riod, can only be supposed to afford very approximate means of estimating the extent of solar activity at that period; while, again, if we wish to study the behavior with respect to size of each group as it passes over the visible disk, this can only be done accurately by the laborious but sure method of measurement.

36. *Method adopted in measuring Carrington's groups.*—In order to accomplish this task, the following method was adopted:—In the first place, in order to obtain the apparent area of any group, a piece of plate glass had a number of lines etched upon it, by means of which it was cut up into squares, the side of each square being $\frac{1}{10}$th of an inch. In order to facilitate reading, each fifth line was painted red.

This piece of glass was then applied (the engraved face toward the drawing) to the group whose apparent area it was desired to measure, and the number of squares and fractional parts of a square occupied by the umbra, the penumbra, and the whole spot was *separately* reckoned and noted down. If it was found that the number of squares reckoned for the whole spot was equal to the sum of those reckoned for the umbra and penumbra together, it was concluded that the measurement was correct.

This method of checking the accuracy of the measurement had the further advantage of giving separately the areas of the umbra and penumbra, thus affording determinations which may be made use of in advancing our knowledge of the subject, although not used by us in our present research.

37. But it is evident that after the apparent area of a group has thus been correctly estimated, this apparent area will not indicate the real size of the group, unless allowance is made for the foreshortening occasioned by its angular distance from the visual center of the disk.

[The practical methods by which this allowance for foreshortening was made are given in detail. The final results of the measurements form an extensive table and give the material for a graphical representation of the observed spotted area for each clear day from the beginning of 1854 to the end of 1860.]

40. *Distribution of Spotted Area over Disk.*—Our next inquiry has reference to the relative distribution of spotted area over different parts of the solar disk. We use the word *disk* in contradistinction to *surface*, because it is evident that, on account of the sun's rotation, the center of his visible disk on one day does not represent the same portion of the solar surface as on another day; indeed from this cause it is well known that sun-spots travel over the visible disk from left to right. It is therefore *one* inquiry to study from day to day the relative distribution of spotted area over different parts of the sun's actual surface, and *another* to study the same from day to day over different

parts of his apparent disk. We have not hitherto attempted the former inquiry (although the subject is not lost sight of, but may come within the range of our future researches), but have confined ourselves entirely to the latter, and now proceed to describe the method of observation adopted.

41. Suppose the visible disk of the sun to be cut up into sections by great circles passing through these poles. These great circles may be regarded as lines of longitude, only, in the present instance, they are not supposed to move round with the sun's surface, but rather to be connected with the earth in such a manner that the plane which passes through the earth is always reckoned the zero or meridian.

Now it is well known that the pole of the sun differs very little from that of the ecliptic, and therefore, in an approximate investigation like the present, we may suppose the two to coincide; these longitudes will thus denote ecliptical longitudes, and the longitude in which the earth is placed being called zero, we may with propriety reckon those to the left negative, and those to the right positive. A sun-spot as it moves across the disk on account of rotation will thus appear at a longitude $-90°$, and vanish at a longitude $+90°$.

The same course will be pursued by the inferior planets Mercury and Venus, which move faster than the Earth; while, on the other hand, the superior planets, which move slower than the Earth, may be supposed to pursue an opposite course, passing across the circles of longitude from right to left.

42. It will thus be apparent that, if the behavior of sun-spots is at all influenced by the positions of the planets, the fact is likely to be discovered by this means. Thus if all the prominent planets be in the same longitude as the Earth, if there be a bond between sun-spots and planets, we should be entitled to expect in such a case some change in appearance or size when the spots for that period pass the central line; if, on the other hand, these planets be together at 20° to the right of the Earth, we might expect some change at 20° to the right, and so on. In fine, one of our objects in the present research is to ascertain the comparative size, at the different ecliptical longitudes in the visible disk, of the whole spotted area for any period, the mass of observations being broken up for this purpose into periods embracing perhaps three or four months, so as to comprehend in each a sufficient number of groups.

43. For this purpose the following plan was adopted. A subsidiary table was formed in which the whole visible disk was portioned out into thirteen parts, each part denoting a day's progress of a spot and embracing every 14° of longitude from $-90°$ to $+90°$. Each of these parts had in this table two columns allotted to it, in one of which the exact longitude of the

spot (with reference to the earth or central point) was noted, while in the other the area *at this longitude* of the whole spot, including umbra and penumbra, was given. *This longitude* of a spot was determined in the following manner. In each of Carrington's large pictures the position of the sun's axis is given. A circular sheet of transparent tracing-calico, of the size of Carrington's sun, had drawn on it lines of longitude for every 10° from −90° to +90°. This sheet being applied in a proper manner to each of Carrington's pictures, the longitude of a spot was thus at once read off to the nearest degree.

The subsidiary table having been thus formed, it was then carefully examined, and all those groups were rejected for which (either on account of their exceedingly small size and consequently doubtful area, or from paucity of observations) a reasonably good line representing their behavior in passing over the disk could not be obtained. Each non-rejected group was then dealt with in the following manner. A curve was drawn, in which the abscissæ represented the longitudes of the visible disk from −90° to +90°, while the ordinates denoted the corresponding area of the group in millionths of the whole hemispherical surface at each of these longitudes. This curve was formed simply by connecting together by means of straight lines the summits of the consecutive ordinates denoting observed areas. From these curves a table was then formed denoting the probable area of each non-rejected group from longitude −62° to longitude +64°, it being thought inadvisable to go nearer the sun's border on either side. Finally, the groups of this table were arranged into consecutive series, each series embracing two or three months, it being supposed that during the course of any one series the planetary configurations retained to a considerable extent the same character. In the following table the results of this subdivision are exhibited.

[The last two columns have been added from a plate in which the positions of Venus and Jupiter are exhibited in connection with a graphical representation of the series of numbers in the table.]

45. Now, *in the first place*, it is evident that during the time embraced in a series the amount of spotted area which crosses one ecliptical longitude is different from that which crosses another,—that is to say, the average size of a spot varies with the ecliptical longitude. This will be seen from a very cursory glance; thus in series IX, X, the average size of a spot attains a maximum at about the longitude of the earth, while in series XI this maximum is much to the right. Since most of these series embrace a considerable number of spots, this behavior may, we think, be considered to be an observational fact.

Table exhibiting the area of the non-rejected groups for the different ecliptical longitudes of the visible disk (longitude of Earth =0°).

No. of series.	Average date of series.	Average size of a group in millionths of the hemispherical area at the following longitudes:—										Longitude of Venus.	Longitude of Jupiter.
		−62°	−48°	−34°	−20°	−6°	+8°	+22°	+36°	+50°	+64°		
I.	1854, Mar. 5	81	90	113	155	229	271	311	330	358	366	+ 10	+120
II.	May 20	105	100	96	80	70	77	78	72	57	39	+ 60	+ 50
III.	Nov. 18	225	261	299	299	298	289	243	239	254	246	+170	−110
IV.	1855, Aug. 25	28	24	21	22	32	43	54	73	84	151	− 20	− 10
V.	1856, Aug. 24	73	78	76	79	82	67	84	60	41	33	−150	+ 40
VI.	1857, Mar. 15	88	94	117	125	167	178	206	211	187	158	− 30	−160
VII.	Aug. 16	111	102	107	106	120	128	108	120	130	135	+ 70	+ 80
VIII.	Nov. 7	94	104	124	132	121	110	108	97	88	81	+140	− 10
IX.	1858, Feb. 1	351	378	394	389	392	401	405	374	325	261	+160	− 80
X.	Apr. 26	141	192	240	295	343	367	365	361	304	211	−120	−140
XI.	July 17	111	118	147	162	173	199	224	238	261	264	− 90	+120
XII.	Nov. 3	231	255	288	316	330	337	349	370	394	418	− 40	+ 30
XIII.	1859, Mar. 8	..	240	229	233	228	218	221	222	197		+ 60	− 70
XIV.	June 22	145	136	128	118	107	100	91	83	79	75	+130	+170
XV.	Aug. 5	342	353	372	405	426	429	414	415	413	410	+150	+150
XVI.	Nov. 11	175	183	195	203	213	226	227	223	213	205	−160	+ 60
XVII.	1860, Feb. 24	123	140	157	168	182	200	195	180	173	161	− 90	− 40
XVIII.	May 16	100	122	141	165	175	185	181	186	184	180	− 30	−110
XIX.	July 2	313	326	321	306	284	271	272	288	251	241	− 10	−160
XX.	Oct. 12	210	225	254	263	255	251	243	221	214	191	+ 60	+110

46. *In the second place*, there seems to be a periodical recurrence of the same sort of behavior. Thus in series I, IV, VI, (XI and XII), XVIII, there is a maximum considerably to the right. The mean dates of these series are:—

I, March, 1854 ....
IV, August, 1855 ....
VI, March, 1857 ....
XI and XII, July to Nov. 1858
XVIII, May, 1860 .....

hence

.....IV=I+17 months.
..... VI=IV+19 "
... (XI and XII)=VI+18 "
XVIII=(XI and XII)+20 "

Mean period, 18·5 "

Also in series II, (after IV), VIII, (XIII and XIV), (XIX and XX), there is a maximum considerably to the left. The dates of these series are:—

II, May, 1854.....
after IV, (say) Dec. 1855 ...
VIII, November, 1857...
(XIII and XIV), March to June 1859, ...
(XIX and XX), July to Oct. 1860

hence

.....IV=II+19 mos.
..... VIII=IV+23 "
.... (XIII and XIV)=VIII+18 "
(XIX & XX)=(XIII & XIV)+15 "

Mean period, 19 "

Again, in series III, V, (IX and X), (XV, XVI, and XVII) the maximum is not far from the center. The dates are:—

III, November, 1854 ..
V, August, 1856.....
(IX and X), Feb. to April, 1858
(XV, XVI, XVII) Aug. 1859 to Feb. 1860..

hence

.....V=III+21 mos.
..... (IX and X)=V+19 "
(XV, XVI, XVII)=(IX, X)+20 "

Mean period, 20 "

Finally, in series IV, VII, XIII, and XIX we have probably a minimum near the center accompanied with a somewhat undecided action. The dates of these series are:—

IV, August, 1855.....	hence	.....VII=IV+24	months.
VII, August, 1857.....		.....XIII=VII+19	"
XIII, March, 1859		.....XIX=XIII+16	"
XIX, July, 1860		Mean, 20	"

The period of recurrence of the same behavior would thus appear to be nineteen or twenty months.

47. *In the third place*, in all these recurrences the progress of the maximum is from left to right, *not* right to left. Thus in series III the maximum is near the center, while in series IV it has gone to the right. The same order is observable in series X and XI, and in fact, throughout the whole twenty series.

48. We cannot see that these phenomena can possibly be explained, unless it be admitted that the behavior of the sun-spots is subject to some external influence, the nature of which will best be determined by the order of recurrence and length of period of the phenomena in question.

In the first place, it is clear that the influence is not stationary, otherwise its period would be one year, that being the time in which the earth (which must be regarded as the standpoint from which these phenomena are viewed) accomplishes one revolution round the sun. Again, since the march of the phenomena is from the left to the right of the earth, this would seem to identify the influence with one of the inferior planets which passes over the sun's disk in this direction (Art. 41), the superior planets going the opposite way.

The period of twenty months will now enable us to determine which of the inferior planets exercises the predominent influence on sun-spots. We have to ask which of the two inferior planets takes twenty months to return to the same position with respect to the earth. This evidently points to Venus, for which the synodical period is 583 days, or between nineteen and twenty months. We may remark that, apart from all observation, if we suppose the various planets to affect the behavior of sun-spots, the influence of Venus should be very great, on account of its nearness to the sun combined with its very considerable size. An examination of the table on p. 326 will give us some idea of the nature of the influence probably exerted by Venus. The average size of a spot would appear to attain its maximum on that side of the sun which is turned away from Venus, and to have its minimum in the neighborhood of this planet.

But, it will be asked, does not Jupiter appear to exert any influence? for although its distance is much greater than that of Venus yet its mass is very great. A reference to the table will,

we think, show that the influence of Jupiter is very great, although not apparently predominating. Thus when Venus and Jupiter are both in opposition to the earth, we might expect a very large average size of spots at the longitude of the earth; but if, Venus being in opposition, Jupiter is in conjunction with the earth, the average size ought to be much smaller. In series X and XV the former is the case, and for these the average size of a spot is exceptionally large. In series V, VIII, and XVI the latter is the case, and for these the average size of a spot is exceptionally small.

We ought here to remark that, although Venus has *apparently* a predominating influence, it may not have so in reality; for it is clear that by the method of observation employed, the effect of Jupiter is more equalized than that of Venus, the former separating from the earth or point of view more rapidly than the latter. Thus, if at the beginning of three months' observation Jupiter were in opposition, it would at the end be 96° distant from the earth,—that is to say, its angular motion with respect to the earth during this period would have been nearly 84°, whereas the angular motion of Venus with respect to the earth under similar circumstances would be only 54°. Thus the effect of Venus during this period would be more nearly equal to the maximum effect of Venus than the effect of Jupiter would be to its maximum effect.

[Having thus endeavored to trace the effect of these two planets on the behavior, with respect to size, of sun-spots in crossing the visible disk, the authors supplement the evidence by means of a curve, exhibiting from month to month the whole amount of spotted area for the whole disk. It is evident that in such a curve we ought to have a high point or great amount of area when Venus is in opposition to the earth; in such a case our *standpoint* is favorable. But, again, we ought to have a maximum when the two influential planets, Venus and Jupiter, unite together in acting upon the sun, even although the standpoint of the earth may not be in the most favorable position. The various maxima of such a curve ought thus to be referable to one of two causes, or to both combined—(1) either to a favorable position of the standpoint, or (2) to a favorable conjunction of planets for action upon the sun. The maxima are shown to be in fact regulated by planetary configurations, and especially by the two causes named.]

50. While the preceding portion of this paper was being printed, a circular issued by Mr. Chacornac has been the means of calling our attention to Carrington's diagram exhibiting the distribution of spotted area in heliographical latitude from time to time, and to the minor fluctuations which occur in his diagram.

We had previously proposed to ourselves a complete investi-

gation into this as the subject of a third series of these researches; but a preliminary investigation of Carrington's diagram has led us to a conclusion which we think of sufficient importance to communicate at once, reserving a more elaborate and accurate investigation to a future occasion.

We think it will very likely be found that, at those periods when the planets Jupiter and Venus cross the solar equator, there will be a tendency of the spotted area to approach the equator, and at those periods when the heliographical latitude of these planets is greatest there will be a tendency for spots to spread out from the solar equator.

Reserving the action of Jupiter to a more complete investigation, we have derived the following result regarding the action of Venus from an approximate method of treating Carrington's diagram. *It would appear that spots are nearest to the solar equator when the heliographical latitude of Venus is* 0°, *and are most distant from the solar equator when this planet attains its greatest heliographical latitude.*

51. *Concluding remarks.*—The following question may occur to our readers, How is it possible that a planet so far from the sun as Venus or Jupiter can cause mechanical changes so vast as those which sun-spots exhibit? We would reply in the following terms to this objection.

We do not, of course, imagine that we have as yet determined the nature of the influence exerted by these planets on the sun; but we would, nevertheless, refer to an opinion expressed by Professor Tait, "that the properties of a body, especially those with respect to heat and light, may be influenced by the neighborhood of a large body." Now an influence of this kind would naturally be most powerful upon a body such as the sun, which possesses a very high temperature, just as a poker thrust into a hot furnace will create a greater disturbance of the heat than if thrust into a chamber very little hotter than itself. In the next place, it is not to be inferred that the mechanical equivalent of the energy exhibited in sun-spots is derived from the influencing planet any more than it is to be inferred that the energy of a cannon-ball is derived from the force with which the trigger is pulled.*

The molecular state of the sun, just as that of the cannon or of fulminating powder, may be extremely sensitive to impressions from without; indeed we have independent grounds for supposing that such is the case. We may infer from certain experiments, especially those of Cagniard de Latour, that at a very high temperature and under a very great pressure the latent heat of vaporization is very small, so that a comparatively small

* It is, however, a possible inquiry whether these phenomena do not imply a certain loss of motion in the influencing planets.

increment of heat will cause a considerable mass of liquid to assume the gaseous form, and *vice versâ*. We may thus very well suppose that an extremely small withdrawal of heat from the sun might cause a copious condensation; and this change of molecular state would, of course, by means of altered reflection, &c., alter to a considerable extent the distribution over the various particles of the sun's surface of an enormous quantity of heat, and great mechanical changes might very easily result.

Again, although we cannot suppose our earth to be nearly so sensitive as the sun, yet the question may be entertained, Does the moon exert an influence of this kind upon the earth?

52. Our readers will, we think, agree with us in dividing the results of this paper into three classes.

We have, *in the first place*, the pure results of observation.

In the second place, we have put forth as an immediate deduction from these observational results a connection between sun-spots and planets. The evidence in favor of this deduction appears to us to be very strong, and we have placed it before our readers in detail that every one may judge for himself.

In the third place, we have, in paragraph 50, ventured to adopt an hypothesis regarding the nature of this action, which must, in the meantime, be considered as a working hypothesis, which may, perhaps, serve to extend our knowledge of the subject.

53. A few words may be allowed us with regard to the history of this question. Professor Wolf has, it is well known, directed attention to a probable connection between sun-spots and planets, derived from the periodicity of the former. With regard to his success in this matter we do not venture to give an opinion; we would only remark that our evidence is of a different nature to that which is capable of being derived from periodicity in the number of spots.

Since our preliminary research into the behavior of sun-spots, a suggestion of the illustrious Galileo, which he appears not to have published from want of evidence, has been brought to our notice by the Rev. William Selwyn. This suggestion advocates a method of research allied to that which we have pursued, and we should be happy to think that our present investigation has tended in any measure to vindicate the sagacity of that renowned philosopher. We venture to think that we have succeeded in demonstrating the great probability of planetary influence, and to hope that this probability may be converted into a certainty, and the subject very far advanced before the next ten-yearly maximum, by the labors in solar photography of the Kew Observatory and other similar institutions.

ART. XXXVII.—*Research on the Ethers of Silicic Acid;* by C. FRIEDEL and J. M. CRAFTS.

[Concluded from p. 171.]

The first distillations were made in vacuo (3–5 millimeters pressure), and the substance used consisted in residues from various preparations of the normal silicate, and of the hexethylic disilicic silicate; both these products had as far as possible already been extracted.

After eight distillations we obtained—

at 60°–115° (Centigrade.)	6 grs.	of liquid.	
115 –135	16 "		
135 –150	8 "		
150 –165	14 "		
165 –180	30 "	Si=18·73	per ct.
180 –200	16 "	Si=19·58	"
200 –220	8 "	Si=20·78	"
220 –260	4 "	Si=21·96	"
260 –300	3 "	Si=22·78	"
300 –320	3 "	Si=23·59	"

The largest portion within narrow limits of temperature, that which distilled 165°–180°, was redistilled in the air; it commenced to distill at 285°, and between this point and 305°, 25 grs. of liquid passed; above 305° there were only 8 grs. This last product contained 19·34 per cent Si.

All the products distilled above, except those which had passed at a temperature higher than 200° in vacuo, were redistilled under the ordinary pressure. There was obtained on the 6th distillation,

175°–215°	6·5 grs.	
215 –235	6.5 "	
235 –243	25·0 "	=hexethylic disilicic ether.
243 –260	10·0 "	
260 –276	15.0 "	
276 –286	10·0 "	Si=17·85 per ct.
286 –294	12·0 "	Si=18·22 "
294 –310	5·0 "	
	90·0	

The portion of the above products containing the more condensed ethers, i. e., the part boiling 243°–310°, was redistilled under a pressure of 58–60mm. ($=\frac{1}{12}$ the ordinary pressure of the air), until the amount of liquid distilling at a given point remained nearly constant in successive distillations.

There was obtained—

	4th distillation.	5th distillation.	
170°–195°	7·0 grs.	6·5 grs.	
195 –205	10·0 "	9·5 "	Si=18·26 p. c.
205 –215	7·0 "	7·0 "	
215 –230	8·5 "	9·2 "	
230 –240	6·0 "	5·0 "	Si=19·50 p. c.
240 –285	7·0 "	6·8 "	
	45·5	44·0	

The portion distilling above 200° in vacuo, and that which distilled above 285° under a pressure 58–60 mm., were redistilled three times under a pressure of 9–10 mm.

220°–235°	5·0 grs.	Si=20·60, C=37·01, H=7·64 p. c.
235 –245	2·2 "	Si=20·99 per ct.
245 –280	6·0 "	Si=21·40 "

Finally, the portion remaining above 280°, was distilled under a pressure of 1–3mm.

270°–320°	1·0 grs.	
320 –360	3·0 "	Si=22·79 per ct.
above 360	2·1 "	Si=23.91 "

The formula of Ebelmen's bisilicate requires 20·90 per ct. Si. The quadrisilicate 28·66 per ct. Si.

We made other distillations of the higher products in vacuo, analyzing the liquid, which passed at different temperatures, and found the results to agree with the foregoing.

Thus after a very prolonged series of fractionated distillations, we not only failed to obtain the bisilicate among the products distilling in the neighborhood of its supposed boiling point, but we also failed to isolate any body having a definite composition and a constant boiling point. The proportion of silica in these condensed ethers increases with the temperature, at which they distill, while that of carbon and hydrogen diminishes, and the relations between these constituents do not lead to any simple formula. Products from different preparations having the same boiling points have nearly the same composition.

It is probable that there are several condensed silicates belonging to some of the types mentioned (p. 166) and that they can not be separated by distillation. It is worthy of notice that in all the bodies analyzed the ratio of carbon to hydrogen is the same as in the radical ethyl.

We also attempted to prepare the bisilicate by following exactly the method given by Ebelmen, but failed to obtain it, either because some precaution was omitted in repeating his experiments, or because the bisilicate does not exist. We will observe that the method of preparation given (distillation without thermometer, above the boiling point of mercury) does not offer a very good guaranty for the purity of the substance.

Silicates of methyl.—When we commenced our research, we tried the reaction of methylic alcohol on the chlorid of silicium; but like Ebelmen* we only obtained a product, that it was impossible to purify, turning brown in the air and possessing a fetid odor. We noticed, that this product always contained chlorine.

After having observed that the radicals contained in the alcohols may replace those contained in the ethers of acids† we thought that this reaction might furnish a method of obtaining the silicate of methyl.

With this object, we purified wood-spirit by a treatment with chlorid of calcium, and after decomposing the chlorid of calcium compound with water and rectifying the alcohol several times with sodium, we sealed it in a tube with silicate of ethyl, and heated the mixture during 20 hours at 210°.

After several fractionated distillations the principal product, isolated from the contents of the tube, was a liquid boiling at 143°–147°, together with products with a much higher boiling point.

The portion boiling at 143°–147° gave on analysis numbers which correspond with the composition of a mixed silicate diethylic dimethylic silicic ether.

I.	Substance, weight, - - - -	0·3035 gr.
	$C\Theta_2$, - - - - - -	0·4320 "
	$H_2\Theta$, - - - - - -	0·2435 "
II.	Substance, weight, - - - -	0·3450 "
	$Si\Theta_2$, - - - - - -	0·1150 "
III.	Product redistilled, 143°–147°.	
	Substance, weight, - - - -	0·2220 "
	$C\Theta_2$, - - - - - -	0·3250 "
	$H_2\Theta$, - - - - - -	0·1840 "
IV.	Another preparation, portion distilling, 145°–147°	
	Substance, weight, - - - -	0·2900 "
	$C\Theta_2$, - - - - - -	0·4315 "
	$H_2\Theta$, - - - - - -	0·2350 "

	I.	II.	III.	IV.	Theory. $Si(C_6H_{16}\Theta_4)$.
C,	38·90		39·89	40·61	40·00
H,	8·94		9·20	9·00	8·88
Si,		15·51			15·55

It is remarkable, that in these experiments the principal product formed, and the only one that was easy to isolate, was this mixed ether, and not the silicate of methyl or the trimethylic mono-ethylic ether, although the methylic alcohol was used in large excess.

* Ann. de Chim. et Phys., [3], xvi, 129. † This Journal, [2], xl, 34.

In an experiment, made with the special object of obtaining an ether containing a larger proportion of methyl, we heated silicate of ethyl during 15 hours at 250° with a large excess of methylic alcohol, then distilled, and heated a second time with methylic alcohol, the liquid, boiling below 150°, but still the greater part of the product passed at 143°–147°. This product redistilled at 145°–147° furnished us the material for analysis No. IV. If the mono-methylic and mono-ethylic mixed ethers are formed, as is probable, it is in a much smaller proportion.

The simultaneous production of condensed ethers with a higher boiling point, noticed above, could only be accounted for by the presence of water in the methylic alcohol used, since we convinced ourselves by experiment, that there was no formation of ordinary methylic or ethylic ether, bodies whose production would equally have accounted for the formation of condensed silicates. The methylic alcohol really loses water by the process; for on employing the same alcohol for a second preparation, there was production of more of the mixed ethers and less of the condensed silicates.

This observation induced us to give greater attention to rendering the methylic alcohol anhydrous; and we discovered, that even 8–10 distillations with sodium and methylate of sodium were not sufficient to make the alcohol perfectly anhydrous. It is probable, that when the percentage of water is reduced to a certain limit, the methylate of sodium is no longer decomposed.

We were more successful in drying methylic alcohol by means of anhydrous phosphoric acids.

Methylic alcohol, distilled twice with sodium, and then with a small quantity of phosphoric acid, boils at 65°·5, loses the disagreeable odor, that it usually has, and smells like common alcohol, and does not turn brown with soda. Purified in this manner, it no longer gives, when heated with silicic ether, more than traces of condensed silicates.

The preceding observations on the difficulty of purifying and drying methylic alcohol led us to suspect, that the bad success of the attempts of Ebelmen and our own to obtain methylic silicic ether by the direct action of chlorid of silicium on the alcohol, arose merely from the impurity of the material employed. The following experiment shows, that this was the case.

Methylic alcohol, purified with the precautions mentioned above and added in small quantities at a time to chlorid of silicium, reacts upon it in exactly the same manner as ordinary alcohol. It does not turn brown more than the latter. Hydrochloric acid is given off in abundance, reducing the temperature of the liquid. When the theoretical quantity of alcohol has been added, the product is distilled, and after a small number

of fractionated distillations, it is easy to separate two principal products, one boiling at 120°–122°, and the other at 201°–202°·5. The first product is almost the only one formed, where the alcohol is perfectly anhydrous; it is the normal silicate of ethyl. The second is the hexamethylic disilicic ether.

The products, obtained in the first preparations, were not entirely pure, and analysis showed that a small quantity of an ethylic compound was present; it therefore became necessary to employ a methylic alcohol, obtained by saponification of the oxalate, and all the preparations were subsequently made with this product rectified successively with sodium and phosphoric acid.

In one operation, made with a portion of methylic alcohol, which had been heated with silicate of methyl in a sealed tube, an excellent means of rendering it quite anhydrous, the whole product of the reaction distilled at 121°–126°. Of this the portion boiling at 121°–122° was analyzed.

I.	Substance, weight, - - - -	0·3400 grs.
	CO_2, - - - - - -	0·3930 "
	H_2O, - - - - - -	0·2440 "
II.	Substance, weight, - - - -	0·9275 "
	SiO_2, - - - - - -	0·3680 "

This product contained $\frac{27}{1000}$ of a per cent of chlorine and we found, that the only way to free the methylic ethers completely from chlorine (probably contained in a chlorhydrine) is to heat them in a sealed tube at 180° with an excess of methylic alcohol. After this treatment the product was distilled again at 121°–122° and on analysis gave:

III.	Substance, weight, - - - -	0·2800 grs.
	CO_2, - - - - - -	0·3255 "
	H_2O, - - - - - -	0·2005 "
IV.	Substance, weight, - - - -	0·4025 "
	SiO_2, - - - - - -	0·1610 "

	I.	II.	III.	IV.	Theory. $Si(CH_3)_4O_4$.
C,	31·56		31·68		31·58
H,	7·98		7·95		7·89
Si,		18·52		18·57	18·42

The density of vapor =5·380. The theory requires 5·264.

Difference between 2 weights of bulb, -	0·9730 gr.
Temperature of the balance, - - -	20°
" " oil bath, - - -	190°
Height of barometer, - - - -	760 mm.
Capacity of bulb, - - - -	333·5 cc.
Air remaining, - - - - -	0·2 cc.

The density of the ether at 0°=1·0589.

The normal silicate of methyl is a colorless liquid, possessing an etheric and rather agreeable odor. It is soluble in considerable quantity in water, and the solution only gives a gelatinous deposit of silica at the end of some weeks. Moisture or aqueous alcohol decomposes it rapidly with formation of condensed products and ultimately of silica. It burns with a white smoke composed of silica.

Hexamethylic disilicic ether is formed, whenever the normal ether is prepared with aqueous alcohol, and it may also be obtained by heating the normal ether with methylic alcohol containing water. It boils, as we have already said, at 201°–202°·5, and resembles the hexethylic disilicic ether very much in its properties.

An analysis gave—

I.	Substance, weight, - - - - -	0·2880 gr.
	$\text{C}\Theta_2$, - - - - - -	0·2960 "
	$H_2\Theta$, - - - - - -	0·1800 "
II.	Substance, weight, - - - -	0·5655 "
	$Si\Theta_2$, - - - - - -	0·2665 "

III. Product remaining in the bulb after the determination of the vapor-density.

Substance, weight, - - - - -	0·3335 gr.
$\text{C}\Theta_2$, - - - - - -	0·3400 "
$H_2\Theta$, - - - - - -	0·2100 "

	I.	II.	III.	Theory. $Si_2(\text{C}H_3)_6\Theta_7$.
C,	28·04		27·80	27·90
H,	6·95		6·99	6·97
Si,		22·00		21·70

The vapor density =9·19. The theory requires 8·93.

Difference of 2 weights of bulb, -	1·2422 gr.
Temperature of balance, - -	24°
" " oil bath, - - -	266°·5 mercury therm.
" " " " - - -	263° air thermometer.
Barometric height, - - - -	759·1 mm.
Capacity of bulb, - - - -	253·25 cc.
Air remaining, - - - -	0·2 cc.

The density of this ether at 0°=1·144.

We have not succeeded in isolating any product of a definite composition with a boiling point higher than that of the hexamethylic disilicic ether, and the result of our experiments has been exactly the same as in the case of the ethylic condensed ethers. The per-centage amount of silicic acid rises with the boiling point. We did not extend our investigations so far as was done with ethylic ethers.

We call attention to the small difference in the boiling points of the methylic and ethylic normal silicate =44°, only 11° for

each difference of CH_2. The difference in the case of methylic and ethylic-disilicic ethers is 33° or 5½° for each difference of CH_2.

The monochlorhydrine of the normal methylic silicic ether was obtained, in the same way as the ethylic chlorhydrine, by heating together during one hour at 150°, three molecules of the ether with one molecule of chlorid of silicium. Almost the whole product boiled at 113°–117° and after several distillations the portion boiling at 114°·5–115°·5 gave on analysis—

I.	Substance, weight, - - - - -	0·5965 gr.
	SiO_2 - - - - - -	0.2295 "
II.	Substance, weight, - - - -	0·2695 "
	CO_2, - - - - - -	0·2305 "
	H_2O, - - - - - -	0·1420 "
III.	Substance, weight, - - - -	0·7255 "
	AgCl, - - - - - -	0·6625 "

	I.	II.	III.	Theory. $SiCl(CH_3)_3O_3$.
C,		23·31		23·00
H,		5·85		5·75
Si,	17·95			17·89
Cl,			22·59	22·68

The density of vapor =5·578. Theory 5·420.

Difference between 2 weights of bulb,	1·2147 gr.
Temperature of the balance, - -	19°
" " oil bath, - -	170°·5
Barometric height, - - - -	766·5 mm.
Capacity of bulb, - - - -	369·5 cc.
No air remaining.	

The density of the liquid at 0°=1·1954.

The monochlorhydrine is a liquid with an etheric odor, burning with a green chlorine flame and giving off a siliceous smoke. It is very easily decomposed by moisture. With methylic alcohol it regenerates the normal methylic silicate. It will be seen in the sequel, that the chlorhydrine can be used for the preparation of mixed ethers.

The Dichlorhydrine of methylic-silicic ether was obtained by heating two molecules of monochlorhydrine with one molecule of chlorid of silicium during one hour at 160°. The reaction is somewhat less easy than in the case of the formation of the monochlorhydrine. The larger part of the product distilled at 98°–103°, and the liquid obtained, boiling at this temperature, after four distillations was analyzed.

I.	Substance, weight, - - - -	0·2565 gr.
	CO_2, - - - - - -	0·1400 "
	H_2O, - - - - - -	0·0855 "

II. Substance, weight, - - - - 0·4480 gr.
SiO_2, - - - - - - 0·1700 "
III. Substance, weight, - - - - 0·9325 "
AgCl, - - - - - - 0·1669 "

	I.	II.	III.	Theory. $Si,Cl_2,(CH_3)_2O_2$.
C,	14·85			14·90
H,	3·70			3·72
Si,		17·68		17·39
Cl,			44·28	44·10

Density of vapor = 5·66. Theory 5·57.

Difference between 2 weights of bulb, - 0·8755 gr.
Temperature of balance, - - - 20°
" " oil-bath, - - - 182°·5
Barometric height, - - - - 761·4 mm.
Capacity of bulb, - - - - 272·75 cc.
Air remaining, - - - - - 0·5 cc.

The density of liquid at 0° = 1·2595. The physical properties of the dichlorhydrine resemble those of the monochlorhydrine.

The Trichlorhydrine of the methylic-silicic ether was obtained by heating one molecule of chlorid of silicium with one molecule of the dichlorhydrine during twelve hours at 220°. It is formed much less easily than the preceding bodies; even after the tube had been heated so long a time, a portion of the chlorid of silicium remained intact. The principal product distilled at near 84°. After several fractionated distillations, the portion boiling at 82°–86° was separated and analyzed.

I. Substance, weight, - - - - 0·2980 gr.
CO_2, - - - - - - 0·0800 "
H_2O, - - - - - - 0·0485 "
II. Substance, weight, - - - - 0·2510 "
SiO_2, - - - - - - 0·0920 "
III. Substance, weight, - - - - 0·4105 "
Cl, - - - - - - - 0·0700 "

	I.	II.	III.	Theory. $SiCl_3CH_3O$.
C,	7·29			7·25
H,	1·81			1·81
Si,		17·05		16·92
Cl,			64·46	64·35

Vapor density = 5·66. Theory, 5·73.

The density was taken by the method of Gay Lussac.

Weight of substance employed, - 0·445 gr.
Temperature of the oil-bath, - - 134°·5 "
Volume of vapor, - - - - 109·0 cc.
Height of barometer, - - - 759 mm. at 23°·5
Height of the mercury in the bell glass above the level of the mercury in bath, 128·2 mm.

Mixed methylic-silicic ethers.—Where the chlorhydrines are treated with an alcohol, they exchange the Cl, for the radical of the alcohol and Θ, and in this manner, by employing different alcohols, mixed normal ethers may be obtained. Ordinary alcohol reacts immediately on the monochlorhydrine with evolution of HCl, and the principal product is trimethylic monoethylic-silicic ether. No chlorhydrine remains undecomposed, and there is no formation of silicate of ethyl, and after the excess of alcohol has distilled, the liquid commences to boil at 133°. There is also a small quantity of a product with a boiling point which corresponds to that of the dimethylic diethylic ether formed.

The product boiling at 133°–135 gave on analysis—

I.	Substance, weight, - - - -	0·2890 gr.
	$SiΘ_2$, - - - - - -	0·1060 "
II.	Substance, weight, - - - -	0·2450 "
	$ЄΘ_2$, - - - - - -	0·3240 "
	$H_2Θ$, - - - - - -	0·1885 "

	II.	I.	Theory. $Si(ЄH_3)_2(Є_2H_5)_2,Θ_4$.
C,	36·03		36·14
H,	8·55		8·43
Si,		17·14	16·86

The density of the liquid at 0°=1·0230.

In order to explain to ourselves the formation of the dimethylic diethylic silicic ether, we examined the alcohol, which distilled after the completion of the reaction.

It distilled in great part at 72°–74°. It was treated with powdered caustic potash to remove the hydrochloric acid it contained in solution, distilled and then left over night in contact with freshly calcinated carbonate of potash.

An analysis of this alcohol gave,

Substance, weight, - - - - -			0·1995 gr.
$ЄΘ_2$, - - - - - -			0·3000 "
$H_2Θ$, - - - - - -			0·2250 "
		$ЄH_4Θ$.	$Є_2H_6Θ$.
C,	40·94	37·5	52·17
H,	12·53	12·5	13·04

Common ethylic alcohol containing 21 p. c. of water would have the same composition; but we ascertained that, when aqueous alcohol was treated in the same way with carbonate of potash, it marks 96 p. ct. on the alcoholometer of Gay-Lussac. The alcohol contained a certain quantity of methylic alcohol, which could only have been formed by direct elimination from the methylic-silicic ether with production of an ether, containing a larger proportion of the radical ethyl. We have before observed, that the dimethylic disilicic ether is the one most readily produced.

This had already been obtained by the action of methylic alcohol on the normal silicate of ethyl.* It is also produced, when the methylic dichlorhydrine is treated with ethylic alcohol.

A product, obtained in this way, and boiling at 143°–146°, was analyzed.

I.	Substance, weight, - - - -	0·2700 gr.
	SiO_2, - - - - - -	0·0910 "
II.	Substance, weight, - - - -	0·2400 "
	CO_2, - - - - - -	0·3485 "
	H_2O, - - - - - -	0·1910 "
III.	Substance, weight, - - - -	0·3635 "
	SiO_2, - - - - - -	0·1225 "

	I.	II.	III.	Theory. $Si(CH_3)_2(C_2H_5)_2,O_4$.
C,		39·56		40·00
H,		8·83		8·88
Si,	15·73		15·71	15·55

The product used in analysis No. III was that which remained in the bulb after a determination of vapor-density.

Density of vapor = 6·178. Theory 6·233.

Difference between 2 weights of bulb, -	0·9569 gr.
Temperature of balance, - - -	21°·5
" " oil-bath, - - -	192°
Height of barometer, - - - -	763·7 mm.
Capacity of bulb, - - - -	279·75 cc.
Air remaining, - - - - -	5·25 cc.

The density of liquid at 0° = 1·004.

The monoethylic triethylic ether, was obtained by treating the monochlorhydrine of the normal ethylic silicate with methylic alcohol.

It boils at 155°–157°.

I.	Substance, weight, - - - -	0·3945 gr.
	SiO_2, - - - - - -	0·1180 "
II.	Substance, weight, - - - -	0·2325 "
	CO_2, - - - - - -	0·3640 "
	H_2O, - - - - - -	0·1925 "

	I.	II.	Theory. $SiCH_3,(C_2H_5)_3,O_4$.
C,		42·71	43·30
H,		9·21	9·28
Si,	13·96		14·43

We repeated with the alcohol, that distilled, the same experiment, that was made, where the monoethylic trimethylic ether

* See page 158.

was prepared, and we found ethylic alcohol mixed with the portion of methylic alcohol, which distilled 73°–77°.

I.	Substance, weight, - - - - -	0·1710 gr.
	$C\Theta_2$, - - - - - -	0·2780 "
	$H_2\Theta$, - - - - - -	0·0955 "
II.	Substance, weight, - - - -	0·1545 "
	$C\Theta_2$, - - - - -	0·2520 "
	$H_2\Theta$, - - - - - -	0·1790 "

	I.	II.	$CH_4\Theta$.	$C_2H_6\Theta$.
C,	44·34	44·51	37·5	52·17
H,	12·69	12·89	12·5	13·04

Therefore in this case there is a replacement of ethyl by methyl in the ether with formation of ethylic alcohol and the dimethylic silicic ether, and doubtless the presence of a small quantity of this latter body explains the small amount of carbon and hydrogen found in the analysis of the monomethylic triethylic silicic ether.

Dimethylic diamylic silicic ether.—In the reaction of amylic alcohol on the monochlorhydrine of methylic ether, the displacement of one alcoholic radical by another was still more strongly marked, for the principal product was a liquid boiling at 225°–235°, which did not have the composition of the trimethylic monoamylic ether, but very nearly that of the dimethylic diamylic ether.

An analysis of this product gave—

I.	Substance, weight, - - - -	0·2425 gr.
	$C\Theta_2$, - - - - - -	0·4780 "
	$H_2\Theta$, - - - - - -	0·2375 "
II.	Substance, weight, - - - -	0·3795 "
	$Si\Theta_2$, - - - - - -	0·0865 "

	I.	II.	Theory. $Si(CH_5)_2(C_5H_{11})_2\Theta_4$.
C,	53·76		54·55
H,	10·89		10·61
Si,		10·64	10·61

The decomposition of this ether cannot be effected by an alcoholic solution of ammonia, and it is necessary to employ an alcoholic solution of soda for the determination of the silica.

In the production of this ether by the above reaction, we again notice the tendency to the production of mixed ethers containing two atoms of each alcoholic radical.

It should be noticed, that action of an alcohol upon an ether with interchange of alcoholic radicals, seems to take place more readily at the moment of the formation of the ethers from a chlorhydrine, than after the ether has been once formed.

The Actions of the Anhydrids of Acids on Silicic Ether.—After having observed the substitution of one alcoholic radical for another in ethers, we determined to try to obtain by a similar reaction the replacement of an alcoholic radical by one contained in an acid. The first experiment made was that of heating the chlorid of acetyl with silicic ether, but we have already stated that the chlorine, and not the acetyl, was introduced into the ether with formation of a monochlorhydrine and of acetate of ethyl.

It next occurred to us to try the action of anhydrous acetic acid, $\left.\begin{matrix}C_2H_3O\\C_2H_3O\end{matrix}\right\}O$, and we found, that by means of this reagent an acetine $Si(C_2H_5)_3$, (C_2H_3O), O_4 could be formed.

35 grams of the normal silicate of ethyl and 13 grams of anhydrous acetic acid, boiling at 138°·5–140°,* were heated during 14 hours at 180°.

After 8 fractionated distillations, the following series of products was obtained—distilled—

77°– 80°	7·0	grs.
80°– 95°	2·5	"
95°–165°	4·0	"
165°–177°	3·0	"
177°–181°	2·5	"
181°–192°	5·0	"
192°–197°	2·5	"
197°–204°	1·25	"
204°–230°	1·6	"
above 230°	5·0	"
	33·75	

The first product, 77°–80°, was acetate of ethyl. According to the theory represented by the equation:

$$\left.\begin{matrix}Si\\(C_2H_5)_4\end{matrix}\right\}O_4+\left.\begin{matrix}C_2H_4O\\C_2H_3O\end{matrix}\right\}O=\left.\begin{matrix}Si\\(C_2H_5)_3\\C_2H_3O\end{matrix}\right\}O_4+\left.\begin{matrix}C_2H_3O\\C_2H_5\end{matrix}\right\}O,$$

11·2 grs. of acetate of ethyl ought to have been produced. About 9 grs. of pure acetate were really obtained.

The products boiling higher were analyzed.

I.	177°–181°—Substance, weight,	-	0·2420 gr.
	CO_2, - - - - - -		0·3900 "
	H_2O, - - - - - -		0·1970 "
II.	178°–182°—Substance, weight,	-	0·3190 "
	SiO_2, - - - - - -		0·0875 "

This product was obtained by redistilling No. I.

* A convenient way of obtaining anhydrous acetic acid is, after rectification on acetic of potash, to rectify on the alloy of zinc and sodium, until the disengagement of hydrogen has become very slight.

III. (obtained by redistilling 181°–192°)
Substance, boiling 183°–193°, weight, 0·2865 gr.
$C\Theta_2$, - - - - - - - 0·4580 "
$H_2\Theta$, - - - - - - - 0·2365 "

IV. 192°–197° Substance, weight, - 0·2790 "
$C\Theta_2$, - - - - - - 0·4400 "
$H_2\Theta$, - - - - - - 0·2005 "

	I.	II.	III.	IV.	Theory. $Si(C_2H_5)_3(C_2H_3\Theta)\Theta_4$
C,	43·94		43·57	42·94	43·24
H,	9·06		9·09	7·99	8·11
Si,		12·80			12·61

The decomposition of the acetine by the alcoholic solution of ammonia is not complete, and an alcoholic solution of soda must be used to make the silicic determination.

The preceding analyses show, that the boiling point of the monoacetine $Si,(C_2H_5)_3,C_2H_3\Theta,\Theta_4$ must be near 190°; but we did not succeed in isolating a pure product by distillation. By the action of potash on the acetine, acetic acid is obtained, showing, that it is really an acetine, which is formed. The acetine is a somewhat oily liquid having an ethereal odor, with something of that of acetic acid in it. The odor of acetic acid becomes stronger, when the acetine has been exposed to the action of moisture.

The product of another operation was distilled under a pressure of only 52 millimeters of mercury, because we feared, that the compound might be decomposed by distillation at a high temperature. The liquid boiling at 135°–145° was first analyzed (I). This was redistilled several times and the product boiling at 135°–140° was analyzed (II).

I. Substance, weight, - - - - 0·4740 gr.
$Si\Theta_2$, - - - - - - 0·1285 "

II. Substance, weight, - - - - 0·4360 "
$Si\Theta_2$, - - - - - - 0·1185 "

	I.	II.	Theory.
Si,	12·64	12·68	12·61 per cent.

Action of Boric Acid on the Silicate of Ethyl.—In the hope of obtaining an ether containing boric acid and silicic acid together, we heated 3 grams of boric acid, which had been previously melted, with 28 grams of silicate of ethyl (2 molecules of boric acid for 3 of silicate of ethyl) during 12 hours at 240°.

The whole of the acid dissolved, and on opening the tube there was no evolution of gas. After six or eight fractionated distillations, products were obtained with a very high boiling point, and a considerable quantity of a liquid with a lower boiling point; of this latter there distilled:

Below 119°	2 gr.
119°–125°	8 "
125°–140°	5 "
	12 "

All these portions below 140° burnt with a green flame and did not contain a notable quantity of silica. They consisted in Ebelmen's boric ether in a state of almost complete purity. The true boiling point of this ether is 119°.

The portion 119°–125° was analyzed.

Substance, weight,	0·2105 gr.
CO_2,	0·3795 "
H_2O,	0·1990 "

		Theory. $Bo(C_2H_5)_3O_3$.
C,	49·19	49·31
H,	10·51	10·27

Supposing all the boric acid to have been converted into boric ether, 12 grams of the latter ought to have been produced. The reaction therefore had resulted, not in the production of a mixed ether containing both the acids, but in the replacement of silicic acid by boric. The products boiling higher than 140° consisted in ethers, containing a large amount of silicic acid, and a residue of silica was left in the flask after the distillation. Boric acid acts on silicic ether in the same manner as water, and not like anhydrous acetic acid. It is possible that this reaction may serve as a means of preparing some of the ethers of other acids that have not yet been obtained.

From all the facts observed in this research, the tetratomic character of silicium appears to us proved in the most convincing manner. It is impossible to find simpler formulæ to represent the composition of the monochlorhydrines and trichlorhydrines of ethylic and methylic silicic ethers, or of the monoamylic-triethylic, monoethylic-trimethylic and monoethylic-triethylic ethers, or of the acetine; and only by returning to the old atomic weight of oxygen, can the hexethylic and hexamethylic-disilicic ethers be written with a simpler formula, since they contain O_7.

The existence of these compounds and their formulæ is interpreted most readily by supposing, as we have done, that the chlorid of silicium, $SiCl_4$, silicic acid, SiO_2, and the silicic hydrate SiH_4O_4 act in the same way as the polybasic acids known in mineral and organic chemistry.

In another paper we intend to publish the results, that we have obtained in studying the compounds of silicium with the alcoholic radicals.

Boston, Dec. 5th, 1866.

ART. XXXVIII.—*On the supposed falsification of samples of California Petroleum;* by S. F. PECKHAM, late Chemist to the California Petroleum Company.

HAVING been almost exclusively engaged during the last eighteen months in both technical and scientific analyses of California bitumens, my attention has been repeatedly called to the small amount of light oils suitable for illumination yielded by these substances, when treated by the ordinary process of fractional distillation. This low percentage of light oil, and consequent inferior commercial value of the crude materials, early led me to compare my own results with those of other experimenters and analysts of California products.

The first reports that I obtained, were published in the prospectus of the Philadelphia and California Petroleum Company. These embraced the details of an examination made by Mr. Peter Collier, under the direction of Prof. Silliman; those of C. M. Warren, Esq., of Brookline, Mass., and those of Prof. J. M. Maisch of Philadelphia. I afterwards received a pamphlet containing an article published in this Journal, vol. xxxix, May, 1865. This article contained the results of the analysis made by Mr. Collier and the report of Mr. Warren, before mentioned. The report of Mr. Maisch was dated March 18th, 1865; that of Mr. Warren, March 31st, 1865; that of Prof. Silliman was without date.

The material operated upon by Prof. S. was said to have come from a spring upon the Simi ranch in Santa Barbara county; and that treated by Messrs. Warren and Maisch was said to be a portion of the same sample. Without concurrent testimony, the similarity of the results obtained by those gentlemen, even by different methods of operation, sufficiently proves the identity of the crude material.

My own results, which I propose to compare with those above mentioned, were obtained by the treatment of petroleums gathered from the natural outcrops known as the Cañada Laga and Pico springs, and two samples, of different density, from the estate of the Hayward Petroleum Co. The Stanford oil springs adjoining and resembling those of the H. P. Co., and a tunnel in the San Fernando mining district, the product of which is a little more dense but otherwise resembles that of the Pico spring, were the only other localities in Southern California, yielding petroleum in any other than the most insignificant quantities, at the time I left that region in June last.

I am perfectly familiar with each of these localities and their products. All the samples treated by me, with but one exception—the lightest sample from the H. P. Co.—were gathered

under my own eye, most of them with my own hand. The exceptional sample was gathered and furnished me under the personal supervision of William H. Stone, Esq., at that time Superintendent of the California Petroleum Company.

My experiments were first confined to the petroleums of the Cañada Laga spring, and the tunnels of the H. P. Co. The great dissimilarity between my results and those detailed in the published reports, led me to inquire of persons familiar with the country, concerning the spring upon the Simi ranch, with the intention of procuring some of the oil for analysis. I was then and subsequently informed that no "green oil" (petroleum) springs existed upon that estate. I then sought the officers of the Philadelphia and California Petroleum Company resident upon their estate, and was informed by them that no oil of sp. gr. corresponding to that given in the reports (average ·8635 = 33·5° Baumé) was to be found upon their property, nor so far as they could learn in that part of the country. I was informed that the lightest oil yielded by any natural outcrop in that section, was that of the Pico spring, situated very near but without the boundary line of the San Francisco ranch. The sp. gr. of this oil, as estimated by myself, is ·8832=28·5° Baumé. I was assured by Mr. Lyon who had had charge of the spring for more than a year prior to June 1st, 1866, that no oil lighter than sp. gr. 28·5° Baumé had ever been obtained from it. I have reason to believe, that before I left Southern California, I visited more of the bituminous outcrops of Santa Barbara and Los Angeles counties, than had ever before been visited by any single person who had written upon this subject; and I was unable to discover any trace of the existence of a natural outflow, yielding lighter material than the Pico Spring.

The specimen of oil from the Pico spring examined by me, was dipped from the pool by Mr. Lyon, under my own eye, May 7th, 1866. The months of May and June are the most favorable season that occurs in that climate, for gathering specimens of the liquid varieties of bitumen. This arises from the fact, that the rains of the winter and spring months, have so swollen the springs, that water which almost invariably accompanies the bitumen comes to the surface, in much greater quantity, and much more rapidly than at any other season; consequently the oil reaches the surface quicker, is less oxydized and thickened, and of less density.

These facts prove, that no petroleum exists upon the Simi ranch, and that no oil had been discovered in Southern California from any natural outcrop, prior to June 1st, 1866, of lower sp. gr. than ·8832=28·5° B.

But one conclusion can be deduced from these premises, viz: the oil examined by Messrs. Silliman, Warren and Maisch, must

have been falsified by admixture of lighter oil, or the oil must have experienced an "organic change" during transmission from San Francisco to New York. The latter supposition is simply ridiculous, even if its incorrectness were not established by proof. I last summer brought a sample from San Francisco to New York, from both the Cañada Laga and Pico springs. Neither of them experienced the slightest change in density.

Having become convinced of the probable falsification of the samples analyzed by the above named gentlemen I was led to more closely compare their results with my own. A study of the details of their analyses elicited the following as the characteristics of this sample of petroleum.

Color, "dark brown." (S.)*
Consistence, "thin and mobile as water." (S.)
Odor "not offensive," (S.) resembling refined Pennsylvania petroleum.
Density, ·861, (S), ·863 (M.), ·864 (W.), average ·863=33·5° B.
Distillation,
"Condensable vapor appeared at 60° C." (S.)
"Boiled at 123° C." (S.)
" Yielded below the boiling point of mercury, 50–60 pr. ct." (S.)
" do. above do. 35–45." (S. and W.)
Sp. gr. of 1st 10 per cent of distillate, ·755. (S.)

		S.	W.	M.
Reserved as naphtha,	per cent,	20	6	7·8
	sp. gr.	·765	·753	·756
Reserved as burning oil,	per cent,	50	42	50
	sp. gr.	·837	·805	·8219
Reserved as lubricating oil,	per cent,	26	25	42·2
	sp. gr.	·896	·910	Residue less in retort.
Loss,	per cent,	4	7	0

The portion reserved as naphtha is of the same sp. gr. at which refiners of Pennsylvania petroleum usually commence to run off burning oil. (M.) If this oil were fractionated the same as is customary in treating Pennsylvania oils, it would furnish, according to—

Silliman.	Warren.	Maisch.
60 per cent.	52 per cent.	57·8 per cent.
Sp. gr. ·815=42° B.	·805=44° B.	·920=41° B.

or about 55 per cent of sp. gr., ·810=43° Baumé.

The burning oil before treatment has very little odor, and that not at all disagreeable. (S., W., M.) Crude oil yields very readily to treatment with sulphuric acid and soda lye, furnishing a refined oil of light color and agreeable odor (S., W., M.), the illuminating qualities of which are not excelled by any.

* Quotations marked "S." are from the report of Prof. Silliman; those marked "W." are from that of Mr. Warren; those marked "M." are from that of Mr. Maisch.

The lubricating oils are of very low specific gravity; of a reddish color in the crude state, and easily rectified. (S.)

The crude oil yields a very large percentage of distillate. The lightest oils are not very light (W., M.), and the odor of the crude distilled oils not more disagreeable than that of many samples of so-called commercial refined oil. (S.)

I recently obtained from the office of the Philadelphia and California Petroleum Company, a small portion of a sample of oil said to have come from the Pico Spring. This was supposed to be a portion of the sample examined by Messrs. Silliman, Warren and Maisch. I also obtained from the same place a small bottle of oil, labelled "crude oil," and bearing upon the seal the initials "B. S." This bottle of oil accompanied specimens of illuminating and lubricating oils received from Prof. Silliman. These two oils were identical in specific gravity and other physical properties. The sp. gr. of these samples is ·868, a difference of only ·005 from that examined by those gentlemen; a difference which may be accounted for, as the result of oxydation during two years.

From an examination of 200 cc. of this oil, I note the following additional characteristics.

With the thermometer bulb immersed in the boiling oil, the oil boiled at 124° C., and with Mr. Warren's condensing apparatus, yielded with the boiling oil at 200° C., ·174; at 220° C., ·250; at 227° C., ·276; with the bath at 200° C., 200 cc. yielded 77·5 cc., or 38·75 per cent of colorless distillate. The sp. gr. of this distillate is ·785=50° Baumé.

From my own examinations of California oils of undoubted authenticity, I gather the following characteristics.

Color.—The color of genuine oils is dark green, when fresh, with marked dichroism. Three samples which I gathered in May and June of last year, when opened in Boston about ten weeks afterwards, appeared of a dark brownish black, having nearly lost their dichroism.

Consistence.—I have seen no oils from natural outcrops that could properly be called "thin and mobile." They are of about the consistence of olive or linseed oil. The oils from tunnels when fresh, are lighter colored, and more mobile fluids.

Odor.—The odor of Southern California petroleums is peculiar; not as offensive as those of Pennsylvania and Canada; but at the same time unlike refined kerosene.

Density.—The density of the oil from the

Cañada Laga spring is, - - -	·9184=23° B.
Tunnel in "Brea. Cañon," H. P. Co., -	·9023=25° B.
Pico spring, - - - - -	·8832=28·5° B.
Lightest oil examined by myself from H. P. Co.,	·875=30° B.
Lightest oil said to have been procured from the extremity of a tunnel 95 ft. in length, H. P. Co.,	·8525=34·5 B.

Petroleum springs existed upon the property of the H. P. Co., prior to the commencement of their operations. I have been told that the oil yielded by them was very dense; lower than 25° Baumé. Upon the property known as the Stanford Oil Springs, tunnels are said to have yielded oil of sp. gr. 31° Baumé, and a tunnel upon the property of the Wylie Springs Oil Co., yielded in June last, oil of sp. gr. 23° Baumé. All of these tunnels have been run since July, 1865.

Distillation.—No condensable vapor appeared from any sample at 100° C.

Pico spring boiled at - - - - - - -	174° C.
Cañada Laga, - - - - - - - -	182° "
H. P. Co., heavy, - - - - - - - -	182° "
Pico spring yielded below the boiling point of mercury,	26·5 per ct.
Total amount of distillate from the Cañada Laga, -	93·75 "

Sp. gr. of first 10 per cent of distillate,

	Cañada Laga, - - - - -	·852
	Pico spring, - - - - -	·805
Tunnels,	H. P. Co., heavy, - - -	·785
	H. P. Co., light, - - - -	·766

None was reserved as naphtha.

Reserved as burning oil sp. gr. ·810=43° Baumé, by ordinary fractional distillation—

Cañada Laga, - - - - - -	3·5 per cent.
Pico spring, - - - - - -	13·5 "
H. P. Co., heavy, - - - - -	28·5 "
H. P. Co., light, - - - - -	35·9 "

The absence of either very light, or very dense oils, is a marked peculiarity of the distillate of Southern California petroleums, when they are treated by direct heat in the ordinary process of fractional distillation. The lubricating oils range in sp. gr. from 25°–29° Baumé.

The odor of the crude distillate is pungent, resembling that of the crude distillate of Pennsylvania petroleum. It yields readily to treatment, and furnishes a refined oil of great transparency, very free from color and of agreeable odor. I have never seen any refined California petroleum of illuminating power equal to the best refined Pennsylvania oil.

The lubricating oils are of very low sp. gr., of a reddish color, and easily rectified.

Mr. Warren's condensing apparatus, with the bath at 200° C., gave from the

Cañada Laga,	18·5	pr. ct., sp. gr. - - -	·810
Pico springs,	18.416	" " - - -	·800
H. P. Co.,	26·08	" " - - -	·800

A comparison of the characteristics of the sample of petrole-

um examined by Messrs. Silliman, Warren and Maisch, with those of the samples of Southern California petroleum, examined by myself, exhibits the following very marked and important differences.

Consistence differing, as water and olive oil.

The odor of one is strikingly similar to that of refined Pennsylvania petroleum; that of the others without resemblance thereto, and peculiar though not offensive.

The density of the one is ·020=5° Baumé, lighter than any oil that could possibly have been procured in that region prior to July, 1865.

The boiling point of the one is 50° C. below, and the sp. gr. of 1st 10 per cent of distillate from the same is ·050 below that of the other.

The absence of light oils, that could be classed as naphtha.

The per-centage yield of burning oil of the same grade is 41·5 per cent more in the one than in the other. The odor of the crude distillate of the one is agreeable, that of the other pungent. The illuminating oils of the one are of superior quality, those of the other are not above the average.

One yields of light oils, not condensed at a temperature of 200° C., 38·75 per cent, of sp. gr., ·785; the others yield only from 11·5 to 18·416 per cent, of a sp. gr. from ·800 to ·810.

These differences all point to the falsification of the oil examined by those gentlemen, by admixture of light oil. It is further proved by the fact, that the lightest oils obtained from the sample furnished them are identical in sp. gr. with the lightest contained in refined Pennsylvania petroleum; by the ease with which the burning oils are rectified, and by their superior illuminating qualities. Finally, their partial California origin is proved by the low sp. gr. of the lubricating oils; by their peculiar red color, and the absence of paraffine.

The following remarkable coincidences seem to indicate that the falsification consisted in the addition of an equal portion of refined Pennsylvania oil of sp. gr. 43° Baumé =·810, to crude oil from the Cañada Laga spring. I tested four different samples of illuminating oil purchased in San Buena Ventura by the Cal. Pet. Co. The sp. gr. of each of them was ·810; and I was told that the larger portion of the illuminating oil sold on the Pacific coast, is of that density. The sp. gr. of the Cañada Laga oil is ·918, which added to ·810 and the sum divided by two, equals ·864 as the average density; ·864 is the sp. gr. of the oil examined by Mr. Warren.

I obtained by ordinary distillation from the Cañada Laga oil 3·5 per cent of distillate, of sp. gr. 43° B.=·810. The results obtained by Mr. Warren were equivalent to about 55 per cent of the same grade. This slight increase is a natural result of

the distillation of a mixture of light and heavy oils, and is also due to the superiority of the results given by Mr. Warren's process over those obtained by ordinary fractional distillation.

Prof. Silliman notices the fact that when 485 cc. were distilled from 1000 cc., the mercury suddenly arose from 320° to 370° C. This remarkable phenomenon clearly indicates that when nearly 500 cc. or 50 per cent had passed into vapor, 485 cc. of which had passed into the receiver, the more dense oils remaining in the retort required a higher degree of heat for their distillation. This phenomenon would no doubt be observed, during the distillation of a mixture of equal parts of refined Pennsylvania petroleum, and a dense oil like that of the Cañada Laga, yielding a distillate, 90 per cent of which distills at a temperature at or above the boiling point of mercury.

It will also be observed, that by Warren's process the Cañada Laga oil yields 11·5 per cent of sp. gr. ·810 or 43° B, and that by the same process the oil examined by him yielded about 55 per cent of the same grade, or 50 per cent plus 5 per cent. I obtained by the ordinary process 93·75 per cent of distillate, a very large amount, the loss being 6·25 per cent. Prof. Silliman obtained 96 per cent, or 50 per cent plus 46 per cent, the loss being 4 per cent, or a little more than half that which I experienced. However these are mere coincidences, striking though they may be.

The foregoing details have been gathered from the results of a large number of experiments, made both in California and in the Eastern states, for the purpose of ascertaining the commercial value of California bitumens. They are offered for the purpose of correcting, what I am confident is an error, and to assist in the dissemination of reliable information respecting California Petroleums.

Providence, R. I., March 6th, 1867.

ART. XXXIX.—*Contributions from the Sheffield Laboratory of Yale College.*—XIV. *On Kaolinite and Pholerite;* by S. W. JOHNSON and JOHN M. BLAKE.

THE study of certain minerals termed pholerite, nacrite, steinmark, and kaolin, leads to the conclusion that a number of substances which are included under these various designations must be classed together and constituted into a mineral species in virtue of possessing chemical and physical properties which admit of precise definition. This species must have a new or unappropriated name, and we propose for it that of Kaolinite, in allusion to the material which furnishes it most commonly and abundantly.

The chemical composition of this mineral was first deduced by Forchhammer from the analysis of a number of kaolins. It is represented by the formula $4\dot{S}i\,3\ddot{A}l\,6\dot{H}$, or by $2\dot{S}i\,\ddot{A}l\,2\dot{H}$. The *per cent* proportions vary considerably according to the atomic weights employed in the calculation. In the table that follows, p. 358, are given the percentages reckoned on the atomic weights adopted by Gmelin (Handbook, English ed.), by Rammelsberg (Handbuch d. Mineralchemie), and by Fresenius (Quantitative Analysis, 4th ed.).

Of the substances which have come under our notice, having the above composition, the most striking is the so-called nacrite, from the Einigkeit mine at Brand, near Freiberg, Saxony. It is described by Breithaupt (Berg. u. Hüt. Zeit., No. 40, 1865) as occurring "in snow-white or yellowish six-sided tabular crystals in fan-shaped or reniform aggregates, and having pearly luster passing into adamantine. Sp. gr. 2·63." The analysis of this mineral made by Richard Müller appeared in Dana's 9th Supplement, and is quoted below.

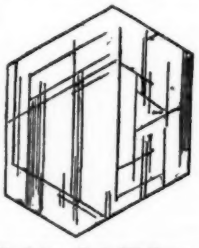
DesCloizeaux, in the Supplement to his Manuel de Minéralogie, p. 549, remarks concerning this mineral as follows: "There has been recently discovered in Saxony a pholerite, at first called *nacrite*, which occurs in large macled hexagonal plates. These plates are composed of six triangular sectors, whose boundaries, though quite vague, nevertheless give indications of composition parallel to the faces of a right rhombic prism approximating the angles 120° and 60°. They cleave easily in the direction of the base of this prism; their interior structure is fibrous, and their surfaces are slightly undulated. Notwithstanding the plates are transparent when sufficiently thin, their action on a polarized beam of parallel rays is very irregular. In convergent light there are seen in each sector the hyperbolas which indicate two diverging optical axes whose plane is normal to the side situated upon the hexagonal contour and is consequently parallel to the principal diagonal of the base of the fundamental prism. The bisectrix is negative and evidently normal to the plane of cleavage. The dispersion of the axes is feeble: at 45° from the plane of polarization it is shown by the symmetrical distribution of the colors about the two hyperbolas, and the separation of the axes is greater for the red rays than for the violet," &c.

Our observations, made on a specimen in the cabinet of Professor Brush, are as follows. The crystals occur in hemispherical groups of about 4 mm. in diameter. These groups have a radiated structure, as is evident from their cleaving into quite thin wedge-shaped laminæ. The laminæ themselves appear to have a radiate structure at right angles to that indicated by the cleavage, for, when viewed by polarized light, dark shades of color branch out irregularly from near the center of the thin

edge of the wedge, and these rotate with considerable uniformity as the plane of polarization is changed. When magnified, the surfaces of the laminæ are seen to be striated in three directions. These striæ intersect at angles of 60° and 120°. The microscopic structure under polarized light gives evidence that the ultimate plates of these groups are twin or compound crystals. In a section ground thin, parallel to the cleavage direction, crystals were seen superposed, the outline of one corresponding to the striæ of another, while, optically, they did not correspond. The portions of crystals thus distinguished by polarized light, were often elongated three or four diameters, and this elongation had the same relation to the plane of polarization as observed in the mineral from Summit Hill to be described presently. Sections of the groups often give an approximately hexagonal outline. The plates of this mineral are flexible, non-elastic, and have a soft, soapy feel.

The white pearly luster of the "nacrite" appears to be due to strata of air included between the separate crystalline plates composing a mass. It, as well as the crystals presently to be noticed from Summit Hill, exhibits the colors of pearl. This can be seen under the microscope by reflected light. If perpendicular illumination be not used, an oblique position of a plate on the slide is most favorable to reflect the light into the instrument and bring out the color. This iridescence may be due either to the fine striæ upon the crystal or to the colors of thin plates of cleavage. As a comparative test, quite thin blown glass, when crushed into a mass, was found to give the pearly luster perfectly, without at the same time exhibiting color; while the thinnest glass in the same condition showed both in a high degree.

A second substance in possession of Prof. Brush was received from Prof. W. T. Rœpper, of Bethlehem, Pa., and was found in a cavity in a coal seam at Summit Hill, Carbon Co., Pa. It bore the label Pholerite. It is a brown scaly powder, which on digestion in hydrochloric acid gives up oxyd of iron to that solvent and becomes nearly white. It has a pearly luster and soapy feel. Magnified fifty diameters, the substance appears made up, for the most part, of well defined crystalline plates. The average size of the plates is ·003 of an inch, the largest are ·005 of an inch in breadth; they are in general extremely thin. They have, as nearly as the mode of measurement employed would show, the angles of perfect hexagons, 120° (see figure). The method used was to draw them upon paper under the camera lucida,



Kaolinite.—Scale 300 diams.

with the aid of a straight edge, to a scale of 650 diameters, and to measure the angles of the drawings with the hand goniometer. Many of these tables are elongated in a direction parallel to one of the sides of the hexagon, sometimes to two diameters. They are striated, and the principal striæ concur with this elongation.

Besides these extremely thin and isolated hexagonal plates, the substance contains prismatic aggregates of similar plates. These aggregates have all degrees of thickness, amounting in some instances to ·003 of an inch. Some of them are obviously homogeneous crystals, composed of closely parallel laminæ perfectly resembling in their aspect prisms of mica. When viewed laterally they are often quite transparent and have deep transverse striæ, which indicate perfect basal cleavage. In other cases the structure of these prisms is less compact and symmetrical; the plates being loosely combined and somewhat separated from each other on one side of the prism.

The longer tables, when seen in polarized light, cease to show a difference of shade on the field, or of tint with the use of selenite, when the plane of polarization of the analyzer is parallel with or at right angles to the axis of elongation. The same occurred with crystals on edge, when the plane of polarization was perpendicular or parallel to the cleavage plane.

The thicker plates, when not in the positions just mentioned, have very evident effect on the polarized beam. This indicates a considerable separation of the optical axes. Like the laminæ of "nacrite," the crystals of this substance exhibit, when properly illuminated, the colors of pearl. When ignited, the substance is seen to increase in bulk, and the microscope shows this to be the result of the exfoliation of the crystals due to the expulsion of their water of combination. This mineral differs from the so-called "nacrite" in not being macled. Some fragments from the exterior of the groups of nacrite crystals resemble this "pholerite" closely, showing evident hexagonal outlines and striæ with the angles 120° and 60°. We found the specific gravity of the purified mineral to be 2·59. An analysis made on 442 milligrams by fusion with carbonate of soda gave the following results:

Silica, - - - - -	45·93
Alumina, and trace of oxyd of iron, -	39·81
Water, - - - - -	14·02
	99·76

The substance described as pholerite by Dr. F. A. Genth (this Jour., [2], xxviii, 251) is of similar character and occurrence. It was found in coal mines at Tamaqua, Pa., in scales of a yellowish white color, which became white on treatment with dilute hydrochloric acid, and at Pottsville, Pa., in snow-white scales of

a pearly luster. Dr. Genth remarks that under the microscope the scales appear to be clinorhombic. His analysis of this substance, after purification by hydrochloric acid, is given below.

The first mention of a crystalline substance with the composition of Forchhammer's kaolin that we have been able to find is by Wöhler, who describes, under the name steinmark, a pale yellow coherent mass which is converted by dilute hydrochloric acid, with solution of a little oxyd of iron, into a white shining powder. (Ann. d. Ch. u. Ph., lxxx, 122.) With help of a lens, Wöhler found it to consist of "shining laminæ, which, when magnified 200 diameters, were seen to be transparent and to consist in part of rhomboidal tables. Before treatment with dilute hydrochloric acid the mass had an earthy fracture which assumed luster by rubbing, an unctuous feel, and adhered strongly to the tongue. Sp. gr. 2·6." The locality was Schneckenstein, Saxony. The analysis by Prof. W. S. Clark, now of Amherst College, is given below.

In response to our application, Prof. Clark has kindly favored us with a fragment of this substance. We observed that it requires to be acted on with hot concentrated hydrochloric acid for some time before falling to a white powder. Microscopic examination of the substance thus purified confirmed our anticipation of its close physical resemblance to the minerals already noticed. It consists of plates and bundles of plates, the largest being ·001 of an inch or less in breadth, and when sufficiently magnified has a great similarity to the kaolinite from Summit Hill. The angles of the plates, as well as of the striæ which they exhibit, approximate 120°. Under a high power the striæ are seen to be formed by the edges of superposed and conformable plates; some loosely aggregated bundles resembled those to be noticed presently, as occurring in the kaolinite from near Richmond, Va. [See note on a subsequent page.]

In 1859, Knop analyzed a mineral of the same composition from Zeisigwald near Chemnitz, consisting of microscopic sharp rhombic plates. (Jahresbericht der Chem., 1859, p. 789.)

Stolba has also published an analysis (see below) of a substance occurring in the coal mines of Schlan, Bohemia, in the form of brilliant white scales, which is obviously kaolinite. (Jour. für prakt. Ch., xciv, 116.)

In his Manuel de Minéralogie, DesCloizeaux, in describing pholerite, remarks, p. 190: "a variety from Lodève, in somewhat contorted scales, exhibits under the polarizing microscope, indications of two quite divergent systems of axes, of which the negative bisectrix is almost normal to the plane of the laminæ; the interior structure otherwise appears highly irregular." This "variety" is the mineral analyzed by Pisani from the same locality (Comptes Rendus, liii, 1072, also Dana's 10th Supplement),

and the words of DesCloizeaux, above quoted, appear to be the first recorded optical observations on kaolinite. Pisani's analysis is given in the subjoined table.

Kaolin is described by nearly all writers as an opake amorphous substance. Some have mentioned it to contain minute transparent plates, but have supposed them to be sheets of mica or other admixture. We have examined microscopically twenty specimens of kaolin, pipe- and fire-clay. Most of these are of unknown origin. In them all is found a greater or less proportion of transparent plates, and in the most of them these plates are abundant, evidently constituting the bulk of the substance. The kaolin from Diendorf (Bodenmais), Bavaria, is perhaps the most finely divided of all the white clays we have studied. When dusted dry upon a glass slide it appears to consist chiefly of masses of a white substance that are opake or nearly so in transmitted light, but, when fully illuminated above and below, have the translucent aspect of snow in the lump. Interspersed among these masses may be seen extremely minute transparent plates of irregular rounded outline. When brought into water the masses are almost entirely resolved into similar transparent plates, most of which are not more than ·0001 of an inch in breadth. This description applies to all the finer plastic clays. Even the dark-colored Stourbridge clay is made up in large part of transparent laminæ, as is a compact sedimentary brownish-gray pipe-clay from Table mountain, Tuolumne Co., Cal. The same is true of the blue fire-clay from Mt. Savage, Md., the white clays of Brandon, Vt., Perth Amboy, N. J., Reading, Pa., Chester Co., Pa., Long Island, and various other white and colored clays from unknown localities. On several specimens of kaolin, especially on one collected at one of the hematite mines at Beekmann, N. Y., we have observed pearly glistening surfaces on the interior of cavities. Viewed in reflected light, by the microscope, these surfaces were seen to be covered with minute scaly crystals, or crystalline aggregates, which, however, revealed no regular outlines.

A white, pulverulent substance, having much the appearance of powdered starch or wheat flour, found near Richmond, Va., was recently analyzed by Mr. Burton in the Sheffield Laboratory. Its composition agrees with Forchhammer's formula (see below), and under the microscope it is seen to be made up for the most part of transparent plates ·001 of an inch or less in breadth, and of prismoidal bundles, obviously composed of loosely aggregated plates, similar to those found in the kaolinite from Summit Hill. These bundles are usually curved, and their length is often several times greater than their breadth. The bundles are fan-shaped in some instances, and the plates are rarely parallel to each other. The edges of these bundles are frequently presented

and in this position they have the greatest effect upon polarized light. They have least influence on the polarized beam when the plane of polarization is perpendicular or parallel to the plates in this position. The separate plates are of broken and irregular outline. Grains of quartz are intermingled.

In four other specimens of kaolin from unknown (probably European) localities, similar prismatic bundles were observed. The bundles were usually curved and irregular; in some instances their length was four or five times their breadth. One of these four kaolins contained hexagonal plates that could be made out with ease under a one-fourth inch objective. Two others, when rubbed between the fingers, assumed a distinct pearly luster; and after this treatment, by which the prismatic crystals were broken up, microscopic examination revealed abundance of hexagonal plates.

Prof. Brush has called our attention to a specimen of fluor from Zinnwald on which occurs a white powdery substance that passes for kaolin. It consists entirely of perfectly definite hexagonal tables averaging ·0005 of an inch in diameter, which are usually thin but sometimes are aggregated into short prisms.

The kaolin, pseudomorphous after prosopite, from Altenberg, Saxony, the analysis of which by Richter (Pogg., xc, 315) is given below, though compact in texture, is found by microscopic examination to be made up also of hexagonal plates and bundles of plates.

The plasticity of clay is a physical character, and appears to have a close connection with the fineness of the particles. The kaolinite of Summit Hill, consisting chiefly of crystal-plates averaging ·003 of an inch in diameter, is destitute of this quality. The nearly pure kaolinite from Richmond, Va., occurring mostly in bundles of much smaller dimensions, the largest being but ·001 of an inch in diameter, is scarcely plastic. The four kaolins of unknown origin which we have described as also consisting largely of prismoid crystals are scarcely plastic, though when rubbed between the fingers they become more soapy to the feel. So too the crystallized kaolinite accompanying fluor from Zinnwald is a scarcely coherent unplastic substance.

The more finely divided fire-clay from Long Island, is more "fat," while the Bodenmais porcelain earth and other clays, in which the bundles are absent and the plates are extremely small, are highly plastic. So, too, the Summit Hill crystals, when triturated in an agate mortar, yield a powder which, when breathed upon, acquires the argillaceous odor, under the microscope perfectly resembles the finer kaolins, and in the wet state is highly plastic and sticky.

Sommaruga has published analyses of two Passau kaolins,

employed in the imperial porcelain manufacture at Vienna, one of which is "fat" and the other "short." The composition of the two is almost identical (see Chem. Centralblatt, 1865, p. 268), and the different degree of plasticity is thus evidently connected with their state of division.

It is possible also that the plasticity of a clay is related to the form of the plates of kaolinite, perhaps to their thickness, but this is a subject that requires further investigation. Our observations indicate that the impurer sedimentary clays are the most plastic. Some of these are perhaps not so fine as "shorter" kaolins. The plasticity may be, therefore, in part due to the impurities.

In the subjoined table are given the analyses of various crystallized kaolinites which have been previously referred to.

Analyses of crystallized Kaolinite.

	$\dot{S}i$	$\ddot{A}l$	$\dot{H}$	Other ingredients.
Kaolinite (Nacrite), Freiberg, Saxony, R. Müller,	47·74	39·48	14·07	....
" (Pholerite), Summit Hill, Pa., S. W. Johnson,	45·93	39·81	14·02	....
" ("), Tamaqua, Pa., F. A. Genth,	46·98	39·65	13·69	0·17
" (Kaolin), Richmond, Va., B. S. Burton,	48·56*	35·61	12·88	2·95
" (Steinmark), Schneckenstein, Saxony, W. S. Clark,	46·76	35·59	13·42	0·94
" (Kaolin), Zeisigwald, Sax., A. Knop,	49·91	35·23	14·86†	....
" ("), Altenberg, " R. Richter,	45·63	39·89	13·70	0·69
" (Pholerite), Lodève, France, Pisani,	47·00	39·40	14·40	....
" ("), Schlan, Bohemia, Stolba,	47·93	36·78	15·29	....
Calculation after Gmelin ($\dot{S}i$=15, $\ddot{A}l$=13·7) requires,	47·19	39·12	13·69	....
" " Rammelsberg ($\dot{S}i$=14·8, $\ddot{A}l$=13·68) requires,	47·05	39·21	13·74	....
" " Fresenius (Dumas) ($\dot{S}i$=14, $\ddot{A}l$=13·75) requires,	46·33	39·76	13·90	....

We find more than thirty analyses of clays, kaolins, and steinmarks, which obviously agree with the formula above given. Some of these analyses appear to have been made on the kaolin as it occurs in nature; others, however, were made on the washed kaolin as prepared for the porcelain manufacture; and in still other cases, as in Forchhammer's investigations, the clay was first exhausted with hydrochloric acid and the analysis was performed on the residue, allowance being made for quartz and substances insoluble in sulphuric acid.

It is obvious then that the basis of many kaolins and clays is a soft, white, transparent, infusible mineral, which crystallizes in forms probably belonging to the trimetric system, has a density of 2·6, when crystallized has usually a pearly luster, is insoluble in dilute hydrochloric acid, and in most of its forms is difficultly decomposed by hot concentrated hydrochloric acid, but is resolvable by hot oil of vitriol and dissolves completely in strong solutions of caustic alkalies. In chemical composition

* Including some quartz. † By difference.

it agrees with the formula deduced by Forchhammer from his analyses of porcelain clays, viz., $3\dot{A}l\,4\breve{S}i\,6\dot{H}$.

This substance is not the nacrite of Vauquelin or Thomson, which contained at the most but one per cent of water. It is not the pholerite of Guillemin, as we shall presently see. The old terms kaolin, steinmark and lithomarge have been so loosely applied that they do not define it.

The massive yellow steinmark from Rochlitz has the composition of kaolinite, but with a portion of the alumina replaced by sesquioxyd of iron. Klaproth's analysis (Chemische Abhandlungen, vi, 287) is as follows:

Silica, - - -	45·25
Alumina, - - -	36·50
Sesquioxyd of iron, - -	2·75
Water, - - -	14·00
Potash, - - -	*trace.*
	98·50

Digested in hot concentrated hydrochloric acid it is scarcely acted upon, but retains its yellow color without falling to powder, as we have observed with a specimen in Professor Brush's cabinet.

The steinmark from Buchberg, analyzed by Zellner, that from Rumpelsberg examined by Rammelsberg (Ramm. Handbuch, p. 576), that from Saszka analyzed by v. Hauer (Jahresbericht der Chem., 1856, 860), and the *severite* of the latter (Ramm., Handbuch, p. 1012), are evidently impure indurated kaolinite.*

Brongniart and Malaguti have investigated a large number of kaolins, and some of the results of their analyses have led to the adoption of the formula $\dot{A}l\,\breve{S}i\,2\dot{H}$ (or $2\dot{A}l\,3\breve{S}i\,4\dot{H}$). But of the 31 analyses by B. and M. but four agree to the above formulæ within 1 per cent of silica, but six within 2 per cent, and but nine within 3 per cent. (See Dana's Min., 4th ed., vol. ii, pp. 249–50.)

Furthermore, the data from which this formula has been proposed, were not derived from the original analyses of the clay, but from these analyses "corrected" by deducting from the total silica (exclusive of quartz), the loss suffered by boiling the kao-

* Halloysite cannot be confounded with kaolinite although it is another hydrate of the same silicate of alumina that exists in the latter. Its formula is $4\breve{S}i\,3\dot{A}l\,12\dot{H}$, or $2\breve{S}i\,\dot{A}l\,4\dot{H}$. The specimens of this mineral from Guatequé analyzed by Boussingault, and those from Houscha and Anglar examined by Berthier, lost one-half their water (8–9 per cent) on drying at 212°, and thus acquired the formula of kaolinite. It cannot be assumed that this loss was due to hygroscopic water, for many substances when dried at 212°, or below that temperature, lose a part or all their crystal water. Thus selenite loses *about* three-fourths of its water at 212°. The quantity is not, however, definite. Halloysite is of much inferior density (sp. gr.=1) to kaolinite, is more easily decomposable by acids, and is without doubt a fairly characterized species.

lin for one and a half minutes with a five per cent solution of caustic potash, this loss being assumed to be accidental hydrated silica. This mode of correction is obviously of no value. On the one hand, the caustic potash might dissolve the kaolinite itself from the more finely divided specimens. Berthier and Rammelsberg have both observed the solution of kaolin in strong potash ley. On the other hand, treatment for so short a time would scarcely suffice to remove all the free silica from a kaolin that contains a large proportion of that substance, if our analytical experience enable us to judge. Again, the analyses appear to have been intended in the first place for technical purposes, and were made, not on specimens selected with reference to their purity, but on the clays in bulk employed in the porcelain manufacture. It is plain that they are not adapted to throw light on the chemical composition of the basis of kaolin. Least of all do they give evidence of the existence of the compound $Al_2Si_2H_2$ in the generality of clays.

We have been able to find but two analyses of kaolin made by Forchhammer's method that lead to this formula. On the other hand, eighteen of Malaguti's uncorrected analyses agree with Forchhammer's formula, and eight of them as closely as those of the crystallized varieties whose composition is given in our table above. It would be strange if, out of all the kaolins that have been studied some should not be nearly pure, except so far as containing fragments of quartz and other minerals insoluble in sulphuric acid. We find thirty kaolins agreeing with Forchhammer's formula and but two with Malaguti's.

The composition of the base of a material so heterogeneous as kaolin is likely to be, cannot in any case be deduced from analyses made on material not evidently pure, no matter how numerous they may be. But the fact that the composition of a substance whose purity cannot be ascertained by mechanical or optical means, agrees with that of another of like origin and occurrence seen to be homogeneous by the help of the microscope, is demonstration that the first is unmixed with foreign matters.

Pholerite.—That other crystallized hydrous silicates of alumina, infusible, insoluble in hydrochloric but decomposable by sulphuric acid, may exist in clays or may form the basis of clays is not at all improbable. In 1825 Guillemin first described, under the name pholerite, a pure white, pearly substance, occurring in the form of small convex scales, soft and friable to the touch, adherent to the tongue, and giving with water a plastic mass. (Ann. des Mines, xi, 489.)

In 1851 Prof. J. L. Smith published analyses of two minerals, one from Naxos, associated with emerylite, and another from Schemnitz, associated with diaspore, which he considered identical in composition with pholerite. (This Journal, [2], xi, 58.)

In 1859 Prof. A. Knop published an analysis of a substance found at Niederrabenstein near Chemnitz, the purest forms of which were white bolus-like masses, seen under the microscope to be aggregates of crystalline scales. This claystone (*felsituff*) Knop referred to pholerite. (Jahrbuch für Min., 1859.)

The steinmark from Georgesstollen, examined by Dumenil, that from Schlackenwald (of radiate structure) analyzed by Rammelsberg, and the Tuesite of Scotland, analyzed by Thomson and by Richardson (Ramm. Handbuch, p. 576), approach Guillemin's mineral in composition, or lie between it and kaolinite.

In the subjoined table is given the composition of these minerals and the percentages required by Guillemin's formula, which is the one that has been deduced from Malaguti's analyses of kaolin, viz., $\dot{A}l\,\ddot{S}i\,2\dot{H}$.

	$\ddot{S}i$	$\dot{A}l$	$\dot{H}$	Other substances.
Calculated, from Dumas' equivalents,	39·30	44·98	15·71	
" by Guillemin,*	40·75	43·89	15·36	
Pholerite, Fins, Guillemin,	42·92	42·08	15·00	
" " "	41·65	43·35	15·00	
" Naxos, J. L. Smith,	44·41	41·20	13·14	1·31
" Schemnitz, "	42·45	42·81	12·92	
" Chemnitz, A. Knop,	39·34	45·90	14·76	
Steinmark, Georgstollen, Dumenil,	43·00	40·25	15·50	0·95
" Schlackenwald, Rammelsberg,	43·46	41·48	13·49	1·57
Tuesite, Scotland, Thompson,	44·30	40·40	13·50	1·25
" " Richardson,	43·80	40·10	14·21	2·13

The correspondence between the calculation and the analytical results is not strikingly close. It is evident that most of the substances analyzed were not homogeneous, and future investigations must decide the yet open question, whether these pholerites are not really impure kaolinite.

It is to be desired that mineralogists having specimens of these pholerites in their possession, should take measures to decide this point by a study of their physical properties, and by instituting new analyses on material properly purified or shown by the microscope to be homogeneous.

New Haven, Conn., March, 1867.

* This calculation by Guillemin is erroneously given by several writers as a third analysis of pholerite from Rive-de-Gier. Guillemin mentions the occurrence of pholerite at Rive-de-Gier, but made no analysis of the substance from that locality.

ART. XL.—*Partzite—a new mineral;* by ALBERT ARENTS, Mining Engineer and Metallurgist.

THIS mineral was discovered early in the year 1865 in the Blind Spring mountains, situated in Mono county, California, and first denoted as a silver ore by Dr. A. F. W. Partz, for which reason I applied to it the above name.

It has hitherto never been found in crystals or of a crystalline structure, but always in amorphous masses generally without luster and rarely of a glistening appearance. Its fracture varies from conchoidal to even, and its color from yellowish-green to blackish-green and black—the lighter-colored portions containing the most silver. Oftentimes the mineral has considerable resemblance to the product obtained during the middle of the raking period in cupellation. The amount of silver it contains ranges between 4 and 12 per cent.

In the veins of the Blind Spring district the Partzite occurs in irregular deposits which are often nodular in shape, and occasionally occupy for a distance of many feet the whole width of the veins.

Its sp. gr. is 3·8; its H.=3–4. Before the blowpipe on platinum it is melted, but with difficulty, to a black slag; on charcoal, and especially by adding soda and pulverized charcoal, a metallic button is easily obtained which bears much resemblance to pure antimony. SO_3, ClH, and NO_5 decompose the mineral even in the cold, liberating oxyd of antimony and forming a copper-silver solution.

An analysis of the mineral shows the following composition:

		Relation of oxygen.		Relation of equivalents.		
SbO_3	= 47·65	7·47	7·47	$\frac{7·47}{24}$ = 0·311	=	1
CuO	= 32·11	6·47				
AgO	= 6·12	0·42	=7·54	$\frac{7·54}{8}$ = 0·942	=	3
PbO	= 2·01	0·14				
FeO	= 2·33	0·51				
HO	= 8·29	7·37	=7·37	$\frac{7·37}{8}$ = 0·921	=	3
	98·51					

From the above it will be seen that for 1 eq. of acid there are 3 eq. of bases and 3 eq. of water. We thus obtain the following formula: $(CuO, AgO, PbO, FeO)_3 SbO_3 + 3HO$.

Of arsenic but slight traces were detected which, however, in all probability were due to the presence of fine reticulations of a brilliant green color, by which the mineral is more or less interwoven.

The Partzite occurs together with argentiferous galena, in veins of a magnitude varying from nine inches to eight feet, and has already become the object of extensive mining operations.

ART. XLI.—*On Contributions to Paleontology, published by the Smithsonian Institution.**

AMONG the recent "Contributions to Knowledge" furnished to the scientific world by the Smithsonian Institution, is the series of publications on systematic Paleontology here enumerated. The importance of these articles demands an extended notice, and the principles followed in their preparation or compilation may be exposed with advantage to students.

Commencing with that which was earliest issued, and which is also the most important, we may congratulate naturalists on the appearance of the first part of Meek and Hayden's "Paleontology of the Upper Missouri." If fullness of detail, joined with conciseness of description and the elimination of characters that are not really pertinent to the group under consideration; if a rigorous comparison of such with related types; and if, finally, a careful revisal of the nomenclature and synonymy of all the groups and species discussed, entitle to a claim of excellence, then is the "Paleontology of the Upper Missouri" preëminently deserving of the fullest meed of praise. It will without question, in such respects, fall behind no work on Paleontology which has yet been published in this country, and is, indeed, the only one in which consistent attention has been paid to details. Mr. Meek, to whom the work is especially indebted for its systematic portion, has long stood among the first of American paleontologists, and these new labors fully sustain his title to this rank.

The part of this work issued carries us through the Silurian and Carboniferous ages, and for the subdivisions, the distribution of Professor Dana has been adopted. The faunas of the several *periods* are successively described, and of such the Potsdam, the Carboniferous and Permian, and the Jurassic are recognized. Subject to such subordination, the species are strictly arranged according to their zoölogical affinities, and under their respective branches, classes, orders, families and genera, and *their* subdivisions when such are recognized. Detailed descriptions are given of the families, subfamilies, and genera, and the genera of the former groups are also enumerated, and in all cases evidence is afforded of acquaintance with the most recent investigations. Not content with taking for granted the correctness of the accepted nomenclature, reference has been made to the history and

* 1. Paleontology of the Upper Missouri.—Invertebrates. By F. B. MEEK and F. V. HAYDEN, M.D. 4to. Washington, April, 1855. pp. 136, pl. 5.

2. Check List of the Invertebrate Fossils of North America.—Cretaceous and Jurassic. By F. B. MEEK. 8vo. Washington, April, 1864. pp. 40.

3. Check List id. of the Eocene and Oligocene. By T. A. CONRAD. 8vo. Washington, May, 1866. pp. 41.

4. Check List id. of the Miocene. By F. B. MEEK. 8vo. Washington, 1864. pp. 32.

original application of each name, and, in some cases, the nomenclature has been so modified that the first impulse of many paleontologists will be to dissent therefrom, but if the rules adopted—those recommended by both the British and American Associations for the Advancement of Science—are accepted, the correctness of such modifications must be admitted. In all cases, the typical species of the genera are enumerated immediately after the diagnoses of their respective genera. Would that such a plan had always been pursued by naturalists! None but the critical investigator of such questions can know how much uncertainty and how many disputes concerning points of nomenclature would have been thereby avoided, and he who, at this late day, and in face of the lessons of the past, still refuses to thus limit a newly established group, is deserving of reproach. If, for example, the simple precaution had been taken by the Messrs. Adams in the "Genera of Recent Mollusca," of specifying the types of their numerous new subdivisions, how much confusion would have been saved! As it is, we must be at a loss to know what types to apply their names to in many cases. Shall we take the first named species? It is only by accident of its position in an alphabetical arrangement that it is so placed, and it perhaps does not agree with the diagnosis, which often defines a very artificial group combining types dissimilar, and violently severed from their allies. Again, how are we to know what species are intended, when no synonymy is given and they are for the first time associated under new genera, by the specific parts of their names alone? As has been intimated, the applicability of the diagnosis is no criterion, and, in several cases, the species intended by the authors have been mistaken. It is a question whether we would not be justified in refusing recognition to names thus proposed, save as in courtesy.

Space will not permit notice of the numerous modifications, introduced in the limitation and allocation of the genera, and of the nomenclature. We may only recall that among Trilobites, several names proposed by Barrande and others, are replaced by prior ones of Corda; among the Brachiopods, several of Pander's and other names have been reëstablished, and the proper affinities of several genera, i. e., *Myalina* Koninck, *Aviculopecten* McCoy, and forms confounded with *Monotis*, have either been first demonstrated or confirmed by reference to their microscopical structure. Of new genera, may be enumerated *Chœnomya** (Anatinidæ), *Grammatodon* (Arcidæ), *Camptonectes* Ag. (Pectinidæ), *Lioplacodes* (Viviparidæ) and *Macrophysa* (Lymnæidæ).

* It is suggested in a foot note that *Chœnomya* might be identical with *Anthracomya* Salter, but that reference could not be had to the original description of that genus: the description of Salter's genus having since come to hand, proves, however, that the two are entirely distinct.

Of questions formerly doubtful and here apparently settled, that of the relations of the fossils, known under the names *Trigonellites* or *Aptychus,* is especially noticeable. These have been regarded as peculiar organisms, shells of Lamellibranchiates, remains of Fishes, the digestive apparatus of Gasteropods and Cephalopods, the valves of pedunculated Cirripeds, and supplementary appendages to the shell of Ammonites or their opercula, and all of these opinions have been more or less satisfactorily shown to be erroneous. Of late years, however, the belief in their pertinence to the Ammonitidæ had been gradually gaining ground. By our authors, it has been suggested that they represent the jaws of Ammonites. It is only surprising that this view had not been corroborated before, and especially after the jaws of *Nautilus* had been made known. Found often in intimate connection with Ammonitidæ and Goniatitidæ, what else could they be but the jaws? The examinations of *Nautilus* had demonstrated, that there was no such gizzard-like appendage, and no operculum, and in such respects had only confirmed what was *a priori* probable. Further it had been shown that *Nautilus* had jaws composed of an inner corneous, and external calcareous layer. The intimate relations of Nautilidæ with Goniatitidæ and Ammonitidæ being admitted, we might then expect to find analogous jaws in the latter, and it might be supposed that the search for such, would have soon culminated in the conclusion that *Trigonellites* represented them. The demonstration thereof could not, however, have been considered complete, till the discovery of the homologues of the upper as well as lower jaw of *Nautilus:* but both having now been found, and in opposition to each other, and in the aperture of the shell of *Scaphites Cheyennensis*, doubt will scarcely be entertained by any competent observer concerning their relations. Many paleontologists of late seem to have been prepared to assent to the opinion that *Aptychus* represented an operculum of *Ammonites*, and in figures it has been represented as fitting into and closing the apertures of Ammonitids with an admirable exactness,* but perhaps accuracy has, in such cases, been unintentionally somewhat

* The *Aptychus* has been represented with edges exactly applied to the walls of the chamber, but we are left to conjecture how it could be extended beyond the aperture of the adult which is much contracted by the inflection of the margin, as in *A. microstoma, A. Humphriesianus, A. Codomensis, A. Gervillii,* &c. In this dilemma, we would be obliged to assume that the "operculum" was variable in size, modified according to age, or present in some types and absent in otherwise very closely related ones—assumptions so bold that few, after due consideration, would be sufficiently brave to entertain the privilege of assuming that the duplication of the "*Aptychus*" was an adaptation to ensure its folding, for extrusion would even be denied to us, as the aperture is contracted from the distal as well as lateral margins.

sacrificed to effect. He who would adopt the theory that *Trigonellites* or *Aptychi* are the opercula of Ammonitidæ and Goniatitidæ, must first admit that the jaws of those animals have never been discovered, and in face of the fact, that almost countless species and innumerable specimens of many have been obtained, while the jaws of other Cephalopods, much less susceptible of preservation than those of living Tetrabranchiates, have been found: he must also necessarily assume that, notwithstanding the very close resemblance of the shells, the animals must have been fundamentally dissimilar, and finally, the anomaly is presented of a *double operculum increasing in opposite directions.* When, finally, it is remembered that the opposed portions of the Aptychoid, described by our authors, exhibit essentially the same relations as to size, &c., that the jaws of *Nautilus* do, and that, like those jaws, *Aptychus* has an internal corneous and external calcareous layer, more scarcely need be said. The difference of form, however, is very great.

Of necessity, some questions of affinity of species described are left undetermined on account of the condition of the fossils, and their solution must be deferred to the future. It is doubtless for this reason, and in order not to give a new name, that the *Valvata? scabrida*, whose affinities even with the family Valvatidæ are regarded as doubtful, is retained in that genus, and *Tropidina*, which it resembles in form, is for its accommodation subordinated to subgeneric rank under *Valvata.* Elsewise, the authors would have doubtless been influenced by the peculiar characteristics of the animal, especially its lingual dentition, and also of its shell, to elevate it to a generic rank, for in the family Viviparidæ, *Lioplacodes* is generically distinguished on slighter conchological differences than those apparent between *Valvata* and *Tropidina.* If we also demur to the retention of *Dentalium* under the Cyclobranchiata; to the extension of Pulmonifera to include the operculate Pulmonates; and to the elevated rank, which is retained for the Rostriferous Gasteropods, we record our chief grounds of difference, but would add in justice to the authors, that they have simply adopted the views regarding those groups generally prevalent.

It may be stated in conclusion that the part issued has 128 quarto pages of text (besides an index of seven pages) and five plates, and if it is added that sixty-six species are described and figured, some idea may be formed of the elaborate treatment to which they are subjected. The generalizations founded on the observations recorded may be expected to appear in the concluding part.

Reverting now to the "Check Lists" above enumerated, we have in them almost a complete catalogue of the invertebrate fossils occurring in the North American beds from the dawn of

the Jurassic to the end of the Miocene Tertiary. The species found in the Jurassic and Cretaceous formations are arranged in a strictly zoological order under those respective heads,* the subordinate divisions of neither being recognized. The Tertiary, however, is subdivided into the Eocene, Oligocene, and Miocene, and the fossils of each epoch (except the Eocene) are arranged according to their structural affinities—or rather, we should say, as those have been interpreted. Of Jurassic species, 35 are enumerated; of Cretaceous, 885; of Eocene, 766; Oligocene, 105, and of Miocene, 775,—a total of 2566 species of extinct Invertebrates of the Secondary and Tertiary ages: to this number must be added previously undescribed species, whose geological or zoological relations were undeterminable, as well as numerous Cretaceous and Tertiary types since described. From this total are also excluded the species discovered in the Triassic beds. The compilation of such lists, unaccompanied even by references to the volumes in which the species are described, is a task of no slight magnitude, especially when all the species are subjected to a critical investigation respecting their affinities, and the care and conscientiousness with which that task has been done, and the knowledge and judgement which have been brought to bear upon it, will be obvious on the most superficial examination of the lists. That there are errors of judgement; that species may be found to have been enumerated several times and even under different genera; and that faults of other kinds may be hereafter detected,—is quite possible, but such failures are inseparable from compilations of this character, although made with the most rigorous care and by the best informed; one of the happy results of such lists is that these errors will sooner be detected and rectified, and that the recurrence of similar ones in the future will, in great measure, be prevented—surely a sufficient boon if none other were furnished! The imperfect condition in which many fossils are found, the inability to examine parts of the shell even which may furnish a good clue to their affinities, the necessity of trusting in the accuracy and interpretations of describers, who may be insufficiently educated, are all elements which must produce more or less error, and generations may elapse before they can be rectified. Under these circumstances, it may not be deemed singular, if views regarding some forms are suggested, differing from those expressed in the classifications of the lists noticed.

The species of the Jurassic, a formation chiefly developed in Dakota and Idaho, have been mostly described in the Paleontology of the Upper Missouri published since the list, and therein one new species—*Viviparus Gillii*—is added.

* This is the first attempt hitherto made, to group our Cretaceous and Jurassic Invertebrates, in accordance with their zoological affinities.

Of the more characteristic Cretaceous types, 111 species of Ammonitidæ, 40 of Inoceraminæ, 9 of *Venilia*, 8 of *Gryphæa*, 7 of *Neithea*, and 19 of *Rudista*, &c., are enumerated, and 13 new genera or subgenera are established for Cretaceous forms. Among observations on other types, is one especially deserving consideration from naturalists; "it is not probable that *any* of the species retained under the name *Fusus* in the foregoing list, belong to that genus" as properly restricted. Apparently few of the species indeed belong to the same family (Fasciolariidæ) with the true *Fusi* or *Coli*, some belonging rather to the Buccinidæ and others with the Cassidulidæ, &c. The mollusca possessing shells of a more or less subfusiform shape require a severe revision by one conversant with the anatomy of the including order; congeneric species have been widely separated from each other, while very diverse types have been combined under one genus, and from this defect the latest works have been by no means free.

The Eocene strata are grouped by Mr. Conrad under three sections—the "Lower and Medial Eocene (Shark River and Claiborne Groups)," the "Shell Bluff Group," represented by the upper part of the Claiborne Bluff, and on the Savannah river, and the "Upper Eocene, or Jackson Group," which derives its names from its development at Jackson, Miss., and which is also represented in the Carolinas, &c. By far the largest number of species is found in the Lower and Medial Eocene, and only five species have been obtained in the Shell Bluff Group: the three groups are believed to hold "few if any species in common." Of the so-called Oligocene species, all—105 in number—are found at Vicksburg, Miss.

Mr. Conrad has treated his subject with his accustomed ability, but occasionally we are led to wonder why certain combinations have been made,—under the Sycotypidæ, for example, the genus *Perissolax* is included, and the combinations of species under genera at least require explanation, before they can be understood. An ordinary observer would be able to discover no generic difference between the so-called *Ficopsis mammillatus* and the typical *Pyrulæ*.* After an examination of almost all the living species of the latter, the conclusion has been forced on us that the species in question is more nearly related to the *P. ficus* than several of the species that no one has pretended to at all isolate; yet it is not only generically separated by Mr. Conrad but united with species having, apparently, no close relation with it. The number of such inconsistencies, however, is not larger than might be expected in so long a list, and detracts little from

* The name *Pyrula* (Lam. 1799 type *Bulla ficus* L.) is provisionally adopted rather than *Sycotypus* or *Ficus*: *Sycotypus*, in the first place, is not congeneric with *Pyrula*, but was based on *Busycon canaliculatum* or *pyrum*, and Browne's names, not being binomial, can scarcely be adopted. *Ficus* is objectionable, as the name had previously been used in botany.

the merit of the work: there are indeed few who have exhibited in their labors such sagacity in the forming of the smaller groups, among Mollusca, and the appreciation of their affinities, as Mr. Conrad.

The Miocene, commencing along our eastern border at Maryland, extends southward to South Carolina, and on the western border, it is developed in California and Oregon, while in Dakota, fresh-water deposits have been referred to that period; it is not, however, by any means certain that these several deposits are synchronous.* In the east, the southern extension of the strata has been referred to the Pliocene, but it is traceable into the northern portion as a continuous formation throughout its extent. For the enumeration of the species of this formation we are indebted to Mr. Meek, but he has in most cases adopted the views of Mr. Conrad. Among the groups that require revision, as to their systematic relations, are the families "Buccinidæ" [=Nassidæ] and Muricidæ [=Muricidæ, Buccinidæ, &c]. In the Nassidæ, some incongruous forms are associated under *Tritia*, especially *T. altilis* and *Bulliopsis*; the latter group has congeners in the Vienna Basin, &c., which have been referred to the genus *Melanopsis*. But the consideration of such questions would transcend the limits of a review. Before closing, we would, however, refer to some praiseworthy features exhibited in the publications under notice.

One rarely seen in paleontological publications, and yet extremely desirable, is the indication by the authors of the supposed affinities of all the genera introduced by them into the system. This contrasts most favorably with the negligence in such respects by many paleontologists, who describe supposed new genera as if they were isolated organisms to which nothing in the earth, or the waters under the earth, or the heavens above, was like. Such descriptions, moreover, are loaded with characters partly family, ordinal, or even classical, and partly specific combinations, which evidently indicate that the authors had no clear idea of the relations of the forms introduced; nevertheless it were to be desired that knowledge and precision in this respect could be exacted. Akin to this is the custom, when hints are offered as to affinities, of comparing to, or considering the new forms as "connecting links" between representatives of widely different groups. Without referring to any known example our meaning may be illustrated by supposing a naturalist, in making known a new type of Litorinidæ, referring to *affinities* (not anal-

* It may be here remarked, that the fossils occurring in Oregon, and first referred to the Miocene by Mr. Conrad, are now considered by him to be of Eocene age, and enumerated in his list; they are also enumerated by Mr. Meek in his list of the Miocene species, and finally, Dr. Carpenter has identified almost all the species with living forms. It is more certain that Dr. Carpenter is wrong in almost all his identifications than that Mr. Conrad was not right in the first instance.

ogies) to the genera *Trochus*, *Bulimus* and *Phasianella:* such extreme cases are not rare in Paleontological literature, and, to say the least, are suggestive of a confusion of ideas which necessarily renders our confidence in the describers very limited. Let us hope that such errors will be more generally avoided hereafter, and that, with such bases as we have in the publications under review, worthy superstructures may be erected, and that the good examples set therein may be followed by at least our own countrymen. T. G.

ART. XLII.—*On the genus Elasmognathus;* by THEODORE GILL.

SINCE my communication on the new Tapiroid to which I have given the name *Elasmognathus Bairdii*, I have been enabled to examine skulls of four more specimens of the species, all essentially agreeing, but offering differences which perhaps indicate sexual variation. The more the skull is examined, the more does the great difference from the other *Tapiridæ* impress the observer; it resembles that of the Asiatic Tapir (*Rhinochœrus Malayanus*) rather than those of the American species (*Tapirus terrestris*, *T. pinchaque*), especially in the abbreviation of the cranial box, and apparently in the form of the maxillary bones behind, as well as of the nasal bones. The abbreviation of the cranial box is a very important peculiarity of the new type and contrasts strongly with the larger one (not only relatively but actually) of *Tapirus;* this abbreviation would seem to entail some of the differential characters, such as the lamellar form of the maxillary bones behind, &c., as the proportions in other respects are nearly similar. Among the genera of Ungulates, there are indeed no two nearly related genera which exhibit differential characters more strongly marked, or of greater value, than *Elasmognathus* and *Tapirus*. In the extent and form of the cranial box, the form and relations of the maxillary bones, the form of the nasal bones, and the *complete* osseous development of the nasal septum, those genera are widely different; and as those differences must be the coëfficients of peculiarities in the face and proboscis and of consequent modification of habits, and as they are supported by numerous minor differences, consistency in our systematic arrangements seems to require that the generic distinction of *Elasmognathus* should be recognized. Among the normal mammals, none except *Rhinoceros tichorhinus* has a nasal septum so completely ossified as *Elasmognathus*.

ART. XLIII.—*On the action of water upon "Carbohydrates" at an elevated temperature;* by O. LOEW.

IT is well known that the carbohydrates are not decomposed with separation of carbon, at a temperature of 170° C. Cane-sugar yields at 160° levulosan and glucose, at 180° caramelan, at 200° caramel, assamar and caramelin, and at about 250° it yields with total decomposition aldehyd, aceton, acetic acid, furfurol and carbon. But the decomposition takes place quite differently if water is present. While dried sugar yields only levulosan and glucose at 160°, it is perfectly decomposed on heating with water in sealed tubes at the same temperature.

This decomposition is accompanied with the formation of carbonic acid and separation of carbon. Very nearly half of the carbon contained in the sugar employed is thus separated. If the black mass contained in the tube, which has a strong acid reaction, is distilled with water and the distillate saturated with carbonate of lead, and evaporated, a salt is obtained giving all the characteristic reactions of formic acid. I obtained the following results on analysis:

0·5800 grm. gave 0·593 sulphate of lead, 0·728 grm. gave 0·210CO_2 and 0·046 water.

	Calculated.	Found.	
Pb	69·69	69·84	=Formiate of lead.
C	8·08	7·87	
H	0·66	0·69	

There is also formed in this reaction a small quantity of humic acid.

The specific action of the water in this decomposition seems to be that of an acid; for if sugar be heated with *alcohol* at the *same* temperature, in sealed tubes, it remains perfectly unchanged; not the smallest quantity of carbon is separated. Further I have found that sugar is not decomposed by heating it with a solution of baryta in heated tubes at 170° C. Beautiful needles of sugar-baryta only are formed.

Water has the same action upon other "carbohydrates." Starch, gum, or milk-sugar heated with water to 170° for about five hours, gives formic acid, carbon and carbonic acid; gum yields the most carbonic acid. There is also formed a peculiar acid, but little soluble in water, though easily in alcohol and ether. I propose to make this acid the object of further study.

ART. XLIV.—*Exploration of Kent's Cavern, Devonshire: Report of the Committee of the British Association, consisting of* Sir CHARLES LYELL, Bart., Professor PHILLIPS, Sir JOHN LUBBOCK, Bart., Mr. JOHN EVANS, Mr. EDWARD VIVIAN, and Mr. WILLIAM PENGELLY (Reporter).*

THE celebrated Kent's Cavern, or Kent's Hole, is about a mile due east from Torquay harbor. It is situated in a small, wooded, limestone hill on the western side of a valley which, about half a mile to the south, terminates on the northern shore of Torbay.

The hills which surround the district consist of limestone, greenstone, clay-slate, and a reddish grit or compact sandstone. The two last are traversed by veins of quartz; and, with the possible exception of the greenstone, they all belong to the Devonian system. Indeed the entire Torquay peninsula is exclusively made up of rocks of this age.

According to tradition, there were formerly four or five entrances to the cavern, of which two only were generally known, the others being merely narrow apertures or slits through which, until they were blocked up from within, the initiated were wont to enter clandestinely. The remaining two are about fifty feet apart, and occur in the face of one and the same low natural cliff, running nearly north and south, on the southeastern side of the hill. The northern entrance is in form a rude triangle, about six feet high and eight feet wide at the base. The southern is a natural and tolerably symmetrical arch, 9½ feet wide at the base, and six feet high. Its form is due partly to a gentle curvature of the strata—the apex of the opening being in the anticlinal axis—and partly to the actual removal, by natural causes, of portions of the limestone beds; the base of the opening, or chord of the arc, consists of undisturbed limestone; so that the entrance may be aptly compared to the mouth of an oven.

From the time of the researches and discoveries which, forty years ago, rendered the cavern famous, to the commencement of the exploration under the auspices of this Association, the southern entrance has been blocked up, the northern alone being used by visitors. The base of the latter is about 189 feet above the level of mean tide,† whilst that of the former is about four feet lower.

The cavern has been known from time immemorial. Even tradition fails to reach back to the date of its discovery. It did

* From the Report of the British Association for 1865.

† A "bench mark" of the Ordnance Survey in the road from Torquay to Ilsham farm, and which is at no great distance from the cavern, is, as Col. Sir H. James kindly informs me, 131·629 feet above the level of mean tide at Liverpool. By pocket aneroid, the base of the northern entrance of the cavern is 57·5 feet above this mark.—W. P.

not, however, attract the attention of scientific inquirers until September, 1824, when Mr. Northmore visited it with the double object, as he stated, "of discovering organic remains, and of ascertaining the existence of a temple of Mithras," and he declared himself "happy to say that he was successful in both objects." He was speedily followed by Mr. W. C. Trevilyan, who, according to the Rev. Mr. M'Enery, "was the first that obtained any results of value to science." Mr. M'Enery, whose name must be forever associated with the cavern, first visited it in the summer of 1825. He was at that time quite inexperienced in cavern researches; for he states that the party which had been induced to accompany was a large one, and that on entering the cavern he "was the last of the train, for he could not divest himself of certain undefinable sensations, it being his first visit to a scene of this nature." The visit was a memorable one; for, separating himself from his companions, and devoting himself to what he conjectured to be a favorable spot, he found several teeth and bones. He thus describes his feelings on the occasion:—"They were the first fossil teeth I had ever seen, and as I laid my hand on these relics of extinct races, and witnesses of an order of things which passed away with them, I shrank back involuntarily; though not insensible to the excitement attending new discoveries, I am not ashamed to own, that in the presence of these remains I felt more of awe than joy." He at once communicated his discovery to Dr. Buckland, and with great energy followed up his "good fortune" for several years. So far as can be ascertained from his memoranda, the date of his latest visit was August 14th, 1829.

Though he at one time intended to publish a narrative of his labors and discoveries, and had made arrangements for the requisite illustrations, the intention was unfortunately abandoned. After his decease, it was feared that his manuscripts had been destroyed or lost; but after experiencing a variety of fortune they passed into the hands of Mr. Vivian of Torquay, who from them compiled a Memoir which was published in 1859.*

In 1840, Mr. Godwin-Austen read a paper before the Geological Society of London, on the "Bone Caves of Devonshire," when he described the results of his investigations in Kent's Hole.

In 1846, the Torquay Natural History Society appointed a committee to conduct an exploration of a small portion of the cavern. Though their object was mainly to obtain specimens for the Society's Museum, very careful attention was given to the positions and associations of all the articles found. A paper embodying the results of this investigation was drawn up

* Cavern Researches. Simpkin, Marshall and Co., 1859.

by Mr. Vivian, a member of the committee, and read in 1847 before the Geological Society of London. A mention of this communication appeared in the 3d volume of the Quarterly Journal of the Society.

Though it may be doubted, perhaps, whether any of the foregoing explorations were conducted with that rigid observance of method which is now held to be necessary, all the explorers are unanimous in stating that they found flint "implements" mixed up with the remains of extinct animals.

In 1858, the results of the systematic and careful exploration of Brixham Cavern, on the opposite shore of Torbay, induced the scientific world to suspect that the alleged discoveries which, from time to time during a quarter of a century, had been reported from Kent's Hole, might, after all, be entitled to a place amongst the verities of science; and from that time various proposals for further investigations have been made. As is well known, these suggestions took a definite form at the last Meeting of this Association, when a liberal grant of money was made, and a committee was appointed for the purpose of further exploration. It is the object of this communication to state what up to this time the results have been, so far as they are at present determined.

The committee have great pleasure in stating that, in reply to their application for permission to make the proposed investigation, the proprietor, Sir L. Palk, Bart., M.P., assured them most promptly that it would "give him great pleasure to place every facility in their hands." He placed the cavern in their exclusive custody, and suggested the most satisfactory arrangement for the ultimate disposal of such objects of interest as might be found.

Though large portions of the deposits were broken up by Mr. M'Enery and his successors, there is still within the cavern a very considerable amount of virgin ground. The committee, however, were desirous of selecting an area in which not only were the deposits certainly intact, but which would not present any very great difficulties in working. After a visit of inspection it was decided to undertake the exploration of the large chamber into which the southern entrance immediately opens. The mode of investigation was laid down, trustworthy and intelligent workmen were engaged (Mr. Charles Keeping, brother of the well-known fossil collector, being the chief), and the work, consigned to the superintendence of the two resident members of the committee, Mr. Vivian and the Honorary Secretary, was commenced on March 28th of the present year.

Immediately outside the cave lay a considerable talus of earth and stones, the upper portion of which, at least, is believed to have been thrown out by Mr. M'Enery, who conducted his re-

searches through the northern opening. It was necessary to cut through this mass, in order to reach and make available the entrance which the committee had selected for their operations. This material was very carefully examined, partly for the purpose of detecting any objects of interest which it might contain, and partly as an initiatory exercise for the workmen.

The cavern is in no part subject to any considerable amount of drip; and no portion of it is drier than the chamber selected for exploration. Since the commencement of the work unusually heavy rains have fallen in the district, but water has entered through the roof at very few points only, and in no instance in such an amount as to produce discomfort or inconvenience.

The following is the succession of deposits, in descending order, which the chamber contained.

1st. Huge blocks of limestone which had manifestly fallen from the roof. Many of them required blasting to effect their removal; and in several instances it was necessary to blast even the masses into which they were by this means divided. One of the blocks measured 11 feet long, 5½ broad, and 2½ thick; hence it contained upward of 100 cubic feet, and must have weighed fully seven tons. In some cases two or three of them lay one on another, and, in a few instances, were firmly cemented together by a separate cake of stalagmite between each pair; whilst others lay unconformably with considerable interspaces. Occasionally, what appeared to be a boss or dome of stalagmite proved to be a block, or two or three small blocks, of limestone invested on all sides with a stalagmitic sheet. Certain masses, lying at some distance from a drop, were without even a trace of stalagmite.

2d. Beneath these limestone blocks there was a layer of mould of an almost black color. It varied from a few inches to upward of a foot in depth.

3d. Underneath the black soil came a cake of stalagmitic breccia, made up of comparatively small fragments of limestone so very firmly cemented together with carbonate of lime as occasionally to require blasting. It was rarely less, but not unfrequently much more, than a foot thick. Everywhere it was firmly attached to the walls, and it occasionally extended completely across the chamber. Not unfrequently, however, the center of the chamber was altogether destitute of this breccia, in some instances, because there is no drip near the area, in others, because it was intercepted by an overlying limestone block.

4th. The breccia is succeeded by the ordinary reddish cave-loam, which contains a large number of limestone fragments, varying in dimensions from bits not larger than sixpences, to

masses but little smaller than those which lay on the surface. They lie at all angles without anything like symmetrical arrangement. In fact the entire deposit is without any approach to stratification. Many of the stones are partially encrusted with calcareous matter, and not unfrequently loam, stones, and splinters of bones are cemented by the same substance into a very tough breccia. The presence of a calcareous drip is more or less traceable everywhere. Hitherto the cave-earth has been excavated to the depth of four feet only. How far it extends below this, or what may be beneath it, is at present unknown. Where it is not covered with the stalagmitic breccia, the black soil lies immediately on it; but the line of junction is everywhere sharply defined. In no instance do the two commingle.

Since the large masses of limestone occur at all levels in the cave-earth as well as everywhere above it, it is obvious that whatever may be the cause to which their fall is attributable, they cannot be referred to any one and the same period. They fell from time to time throughout the accumulation of the cave-earth, they continued to fall whilst the stalagmitic breccia was in process of formation, as well as during the introduction of the black mould, and they are amongst the most recent phenomena which the cavern presents. And even of those which lie on the surface, there is conclusive evidence that in some cases a considerable interval of time must have elapsed between the fall of two blocks lying one on the other—an interval sufficiently great for the formation of the cake of stalagmite between them, and which is sometimes fully six inches thick. There can be little doubt that some of them fell very recently, even when measured by human standards.

It is by no means easy to determine the cause which threw them down. To call in the aid of convulsion seems undesirable, since it would be necessary to do so very frequently. Moreover, it may be doubted whether anything short of a violent earthquake would be equal to the effect. Though the roof of the chamber is of very great span and entirely unsupported, and though it presents appearances which are not calculated to inspire confidence, the violent concussions produced by the frequent blastings already mentioned, blastings which not unfrequently throw masses of limestone, weighing upward of a ton, to a distance of several feet, have never brought down even a splinter.

The fall of the blocks has sometimes been attributed to changes of dimensions in the roof arising from changes of temperature; but the fact that the cavern temperature is all but constant throughout the year, seems fatal to this hypothesis.

The masses lying on the surface were a sufficient guarantee that the deposits beneath them remained intact. There can be

no doubt that they are at once a proof and the cause of the undisturbed character of the soil they cover. A portion of the cavern so easily accessible as is this chamber, would not have been spared by Mr. M'Enery, but on account of some great difficulty or discouragement; and in fact he states that the fallen masses completely foiled him in his attempts to make explorations in it, excepting in one branch some distance south of the area selected by the committee. Their own characters, moreover, render it absolutely certain that the deposits have never been violated.

The following is the method of exploration which has been observed from the commencement, and which it is believed affords a simple and correct method of determining the exact position of every object which has been found.

1st. The black soil accessible between the masses of limestone on the surface was carefully examined and removed.

2d. The limestone blocks occupying the surface of the deposits were blasted and otherwise broken up, and taken out of the cavern.

3d. A line, termed the "datum line," is stretched horizontally from a fixed point at the entrance to another at the back of the chamber.

4th. Lines, one foot apart, are drawn at right angles to the datum line, and therefore parallel to one another, across the chamber so as to divide the surface of the deposit into belts termed "parallels."

5th. In each parallel the black mould which the limestone masses had covered is first examined and removed, and then the stalagmitic breccia, so as to lay bare the surface of the cave-earth.

6th. Horizontal lines, a foot apart, are then drawn from side to side across the vertical face of the section so as to divide the parallel into four layers or "levels," each a foot deep.

Finally, each level is divided into lengths, called "yards," each three feet long, and measured right and left from the datum line as an axis of abscissæ.

In fine, the cave-earth is excavated in vertical slices or parallels four feet high, one foot thick, and as long as the chamber is broad where this breadth does not exceed 30 feet. Each parallel is taken out in levels one foot high, and each level in horizontal prisms three feet long and a foot square in the section, so that each contains three cubic feet of material.

This material, after being carefully examined *in situ* by candlelight, is taken to the doorway and reëxamined by daylight, after which it is at once removed without the cavern. A box is appropriated to each yard exclusively, and in it are placed all the objects of interest which the prism yields. The boxes, each

having a label containing the data necessary for defining the situation of its contents, are daily sent to the Honorary Secretary of the committee, by whom the specimens are at once cleaned and packed in fresh boxes. The labels are numbered and packed with the specimens to which they respectively belong, and a record of the day's work is entered in a diary.

The same method is followed in the examination of the black mould, and also of the stalagmitic breccia, with the single exception that in these cases the parallels are not divided into levels and yards.

With very rare exceptions the cavern has been visited daily by one, and frequently by both of the superintendents; and monthly reports of progress have been regularly forwarded to Sir Charles Lyell, the chairman of the committee.

Though it would be premature to attempt anything like an exhaustive list, it may be of interest to furnish a brief and general account of the objects which have been found.

Of the articles met with in the black mould, those occurring *between* the fallen masses of limestone have been kept distinct from such as have been detected *beneath* them. Such a division, however, is not rendered necessary by the characters of the objects themselves, and will not be attended to on the present occasion. In this category also may be placed the greater number of the specimens found in the talus outside the cavern. The collection is of a various miscellaneous nature. It consists of stones of various kinds, human industrial remains, charred wood, bones of various animals, marine and land shells, and the broken shells of hazel-nuts. It passes from the rabbit's nest lined with clean dry fur and containing a couple of fresh green ivy-leaves, and numberless fragments of wine and porter bottles flung away by parties who have visited the cavern mainly from a love of frolic, back to the age of bronze implements and of flint-flakes, and probably represents from fifteen hundred to two thousand years.

The stones are in most cases well rounded, and, at least, some of them are of marine origin, since they are distinctly lithodomized. They consist of limestone, quartz, red grit, greenstone, and flint; all except the last derivable from the rocks of the immediate district, and were probably obtained from the neighboring beaches, where also the flints were perhaps found; for though there is no flint *in situ* within five miles, it is a well-known fact that such pebbles are met with on existing beaches at much greater distances from any known accumulation of flints in place. The rounded stones are extremely numerous in the black mould, and were undoubtedly selected and taken to the cavern; but for what purpose it may not be easy to determine. There are also several pieces of hard greenish-grey grit of an

elongated form, which were perhaps used as whetstones. Angular pieces of slate are also numerous. They are probably fragments of articles fashioned by man, as occasionally a piece is met with which is obviously a portion of a curvilineal plate. Such plates are mentioned by Mr. M'Enery, who supposes them to have been used as covers for earthenware vessels. The human industrial remains consist of articles in bronze and in bone, pottery, spindle-whorls, and flint-flakes. The bronze articles are a fibula, the bowl and part of the stem of a spoon, a spear head, a fragment of a socketed celt, two or three rings, one coil of a helical spring, a pin about $3\frac{3}{4}$ inches long, and an object resembling a horseshoe in form, but not more than an inch long. In this connection may be mentioned a lump of metal which, from its general appearance, would be termed copper ore, but from its interior, a small portion of which has been exposed accidentally, it is probably native copper, or a mass of metal which has been smelted. A similar mass mentioned by Mr. M'Enery, is said to have been analyzed "by Mr. Phillips and found to be pure virgin ore." Much of the pottery, excepting one small piece, undoubtedly Samian, is extremely coarse, and in most cases it is unglazed. A large number of fragments have been found, but nothing approaching a perfect vessel. They are generally ornamented, and from the different patterns, as well as from other facts, it may be concluded that they represent a considerable number of utensils. One piece probably formed part of a vessel in which things were burnt, as on its inner surface there is a firm admixture of clay and small bits of charcoal. Much of the pottery is without doubt of Roman age.

The objects fashioned in bone are a comb, which in size and outline resembles a common shoe-lifter having teeth cut in the broad end; a spoon, neatly formed of a portion of a rib, and measuring about 6 inches long and $\frac{9}{16}$ths of an inch broad; a chisel about $2\frac{6}{16}$ths inches in length, and at its broad end $\frac{4}{16}$ths of an inch in width; a wedge, somewhat rudely fashioned out of a horn or antler; two small fragments which appear to be portions of combs, and one of which bears traces of ornamentation; and an article about 3 inches long, apparently the handle of some tool.

The spindle-whorls are formed of different materials, such as Devonian red grit, one of the harder varieties of Triassic sandstone (rocks abundant in the neighborhood), a somewhat coarse, greenish, schistose rock not found near the district, and Kimmeridge coal. They differ somewhat in dimensions and in workmanship; some being well finished, whilst others are so roughly made as to render it safer perhaps to call them simply "holed stones." With them may be mentioned a large bead, which ap-

pears to consist of amber or some analogous substance; and a small, holed, ellipsoidal fragment of limestone, which was perforated probably by some lithodomous mollusk.

The flint-flakes are four in number, two of dark and two of light or white flint, the latter being the best formed. The light color is more or less superficial, the center being of a dark gray.

The charred wood is very abundant. Some specimens are undistinguishable from prepared charcoal, whilst others are obviously nothing more than partially burnt sticks, some of them of considerable size.

Bones are extremely numerous. They are more or less discolored, and have lost a considerable portion of their weight.

It may be doubted whether the entire elements of any skeleton have been found lying together. Amongst them there are the relics of pig, deer, sheep, fox, wolf (?), bat, hare, rabbit, with smaller rodents, birds, and various kinds of fish. Some of them appear to have been exposed to the action of fire.

The land shells are principally various kinds of snail, the larger forms being the most prevalent. They occur in all stages of growth, and thus render it probable that they had established a colony in the cavern. Amongst the marine shells are the limpet, whelk, oyster, cockle, mussel, pecten, solen or razor-shell, and the internal shell of the cuttle-fish, *Sepia officinalis*. From the unrubbed condition of the last, it was probably not found cast ashore on the beach, but taken directly from the cephalopod to which it belonged.

The source of the shells of hazel-nuts is not far to seek. They were no doubt obtained from the wood in which the cavern is situated, and were perhaps carried in by small animals whose homes were under the fallen masses of limestone where the shells were found. Most of them are perforated at one end.

In passing below the black mould we first encounter the stalagmitic breccia. This the workmen carefully break into small fragments, in order to detect any articles of interest imbedded in it. The search, though not very productive, has not been quite fruitless. In the breccia have been found charred wood, marine and land shells, and bones of various animals, some of which perhaps are extinct.

Immediately beneath this cake we enter the red cave-loam, and at once find ourselves amongst the relics of several species of extinct animals. The only differences in the four successive levels in which, as already stated, the red loam is taken out are simply that the first or uppermost is the poorest, and the third, perhaps, the richest in osseous remains; and that the three lower levels contain a large amount of minutely comminuted bone, of which there are very few instances in the uppermost foot. In other respects the levels are the same—everywhere the

same in the materials which form the staple of the deposit; in the occurrence of pebbles of various kinds of rock, which differ from those in the overlying black mould only in being less numerous; in the presence of bones in the same condition and representing the same species of animals; and in yielding "flint implements" of the same types. It will not be necessary, therefore, to describe each level separately or in detail.

The bones found below the stalagmite are heavier than those met with above it. This distinction is so well marked and so constant as to be characteristic. It would be easy to assign them to their respective deposits by their specific weights alone. Most of those from the red loam are but little discolored, indeed some of them are of chalk-like whiteness. A few, however, occur here and there which have undergone a considerable amount of discoloration, a consequence, probably, and also a proof of a greater degree of exposure before their inhumation. On most of the latter, certain lines and patches of lighter color not unfrequently present themselves, which may be likened to such as are sometimes left by mosses or lichens on objects of which they have grown.

A large number of bones, including jaws, teeth, and horns, are scored with teeth-marks, clearly the work of animals of different kinds. Some of the long bones are split longitudinally. Many appear to have been rolled, including most of those which have been gnawed; and in the case of the latter, it is tolerably obvious that the rolling was subsequent to the gnawing. Some of those found beneath the large masses of fallen limestone are in a crushed condition, and thus apparently attest the fact that the deposit on which they lay, and on which the blocks fell, was of compact nature, and capable of firm resistance.

The minutely comminuted bone already spoken of, is commonly found converted with loam and stones into a firm breccia. Not unfrequently, however, it occupies the hollow cavities of some of the larger bones. With it there sometimes occurs a cream-colored substance, which in a few instances has been met also in the form of small detached lumps having a low specific gravity. This, as well as some of the comminuted bone, has been supposed to be of fæcal origin.

In cleaning the bones it is frequently found to be impossible to remove entirely the earthy matter from them. They are at least partially invested with a thin film, which defies the brush and water. On drying, however, this matter commonly scales off, and proves to be a paste or paint composed of loam and carbonate of lime, the latter probably derived from drip from the roof.

Large portions of the osseous remains occur in the forms of fragments and mere splinters. The identifiable parts are chiefly

teeth, which are extremely numerous. Amongst the Mammals represented, there are certainly the Cave-bear, Cave-lion, Cave-hyæna, Fox, Horse (probably more than one species), Ox, several species of Deer, the tichorhine Rhinoceros, and Mammoth. Remains of the Hyæna are probably the most abundant, after which come those of Rhinoceros and Horse. The relics of the Mammoths (both molars and tusks) are those of very young individuals.

It has already been hinted that "flint implements" occur everywhere in the cave-earth mixed up with the remains of extinct Mammals. Several of them were found in the presence of, and some of them by, the superintendents. Like the bones, they are at least abundant in the uppermost foot, and occur in greatest numbers in the lowest zones. Altogether, and without reckoning doubtful specimens and numerous chips, nearly thirty "implements" have been dug out. Though the designation of "flint" is given to all, some of them are perhaps of chert. Of the flints properly so called, some are of a dark, and others of a light-grey color, whilst a third kind are almost white, and have a porcellanous aspect. With the exception of three, they are all of the kinds known as flakes—flat on one side, and more or less carinated on the other. Some of them are fragments only, others were found broken in the deposit with the parts lying in contact, whilst others again are perfect. Some of the broken specimens of the white variety show that they are not of this color throughout their entire mass, but have a dark central axis or core. The flakes agree in character with those in the black overlying mould. The excepted three are of chert, and are worked on both sides. They were found in the second, third, and fourth levels; one in each. That from the second foot is about $4\frac{3}{4}$ inches long, and, where widest, $2\frac{1}{2}$ broad. At one end it tapers to a point, and narrows to no more than $\frac{3}{4}$ of an inch at the other. In outline it is rudely a segment of a curvilineal figure, and is slightly falciform. The inner or concave margin is the cutting edge. Unfortunately the tip of the pointed end was broken off after exhumation. Those from the third and fourth levels are more highly wrought "implements." They are worked to an edge around the entire perimeter. In outline they are rather ovoid than elliptical, being narrower at one end than at the other. That from the third foot measures $4\frac{1}{2}$ inches in length, and its greatest breadth and thickness are respectively $3\frac{1}{4}$ inches and $\frac{3}{4}$ of an inch. That found in the fourth zone, the lowest yet reached, is the most elaborately finished "implement" of the series. It is lighter in color and somewhat smaller than the preceding two, its dimensions being $3\frac{1}{2}$ inches long, $2\frac{1}{2}$ broad, and $\frac{3}{4}$ in thickness.

Without intending at present to enter on the consideration of

all the bearings of the entire evidence produced, the committee feel at liberty to express their conviction that it is totally impossible to doubt either the human origin of the "implements," or their inosculation, in undisturbed soil, with the remains of the Mammoth, the Cave-bear, and their extinct contemporaries.

Nor are these the only indications of human existence found in the cave-earth. Several small pieces of burnt bone have been met with in the red loam, some of them loose and detached, others of small size and incorporated in the breccia composed of loam, stones, and comminuted bone.

Mention has been made already of the occurrence in the cave-earth of rounded stones not derivable from the limestone hill in which the cavern is situated. It seems probable that at least some of them were selected and taken there by man; though it may not be easy, perhaps, to determine in all cases for what purpose. But, waiving this point, there are two stones which must not be hastily dismissed. The first of them is $4\frac{3}{4}$ inches long, and something less than one inch square in the section. It is a mass of hard purplish-grey grit, and is undoubtedly a whetstone, or rather a portion of one. It was found in the first level of the cave-earth, in a small recess or cavity in the northern wall of the chamber, immediately beneath a projecting stratum of limestone *in situ*. In this cavity the stone stood with its longest axis vertical. The superintendents were inclined to the opinion that it had slipped through a hole into the cavity at a comparatively recent date; and they diligently set to work to find the means of its ingress. Here, however, they were completely foiled. There was no hole or passage, vertical or lateral, by which the cavity could have been entered. Not only, as has been said, was there a thick stratum of limestone *in situ* immediately over the recess, but over this again, as well as over the red loam, there was a thick compact mass of stalagmitic breccia, consisting of large and small pieces of limestone firmly cemented, and having a height of fully eight feet; the whole of which was removed before the cavity was disclosed or its existence suspected.

The second stone is a rude flattened spheroid, formed from a pebble of coarse, hard, red sandstone, and apparently used for breaking or crushing. Its diameters measure $2\frac{3}{4}$ and $1\frac{3}{4}$ inches. It was found in the second level of the red cave-earth, over which lay an enormous block of limestone, but no stalagmite.

In addition to the pleasure which always attends scientific discovery, the committee have had the gratification of confirming most of the statements of their predecessors. Any differences observable between the statements now made and those of the earlier investigators arise from defective, not conflicting evidence. For example, the committee have not yet been so fortunate as

to find the remains of *Machairodus latidens*, mentioned and figured by Mr. M'Enery,* nor of *Hippotamus major*, alluded to by Prof. Owen† as occurring in the cavern; nor have they found anything in the least degree calculated to bring the statements alluded to into discredit. Again, so far as their researches have gone, the committee have not, like Mr. Godwin-Austen, found the bones of man mixed up, in undisturbed soil, with those of extinct animals;‡ it will be seen, however, that there is no *à priori* improbability in the statement of the distinguished geologist just mentioned; and the committee would remind such as may be disposed to attach importance to the fact that men's bones are not forthcoming as readily as their implements, that in the black mould, as well as in the red loam of the cavern, the only indication of man's existence are remnants of his handiwork. Pottery, implements and ornaments in bone, metal, and stone, the remnants of his fires, and the relics of his feasts are numerous, and betoken the lapse of at least two milleniums; but here, as well as in the older deposits below, the committee have met with no vestige of his osseous system.

In conclusion, the committee would observe that the value of their labors is not to be measured by the discoveries, or rather the rediscoveries, which they have made. They have not only disinterred a valuable body of fact, but with it a confirmation of the concurrent statements of M'Enery, Godwin-Austen, and the committee of the Torquay Natural History Society; and have thereby more than doubled the amount of trustworthy evidence which they have themselves produced.

ART. XLV.—*Additional Notice of the Cohahuila Meteoric Iron;* by CHARLES UPHAM SHEPARD.

PROF. F. SHEPHERD having put me in communication with Maj. E. M. Hamilton, in reference to the locality of Bonanza, New Mexico, I have derived from this persevering explorer several interesting particulars concerning these extraordinary masses that appear worthy of publicity.

Major Hamilton states that Bonanza is about thirty or forty miles north of Santa Rosa, but much farther to the west. Residents of the vicinity told him, it had only once before been visited by any traveller, and this was fifteen years ago, when an Englishman had been deputed thither in an official capacity, to determine whether the iron could be applied to any useful pur-

* Cavern Researches, p. 32, and plate F. (8vo edition).
† British Fossil Mammals and Birds, p. 410 (1846).
‡ Trans. Geol. Soc., Second Series, vol. vi, part 2, pp. 444 & 446.

pose. He reported it as having no value, for the reason that it would cost more to divide the masses, sufficiently to fit them for transportation, than the metal was worth.

Major Hamilton saw thirteen pieces, twelve of which had never been removed, and one small mass of about seventy-five pounds, that had been carried to the village of Santa Rosa. The area within which the twelve masses lie, is between one and two miles in diameter.

The largest mass projects two, or two and a half feet above the ground, and is some three feet long, and a little less in width. How far it is buried in the earth is unknown. Their surfaces are all smooth, without offering any projecting points. They are quite black and entirely free from rust. In shape, they are more or less spherical, and much resemble the time-worn boulders in the beds of rivers. Some of the smaller of them, are estimated to weigh between two and three thousand pounds.

Major Hamilton thinks it might be possible to cut off pieces of a few pounds weight, provided suitable tools for the purpose could be procured, though the operation would be attended with much difficulty.

The smaller masses might be transported across the Rio Grand into the United States, at an expense of fifteen hundred dollars each. The Mexican authorities would have no objections to their removal as they attach no value whatever to them.

Analysis.—The fragment analyzed by me, weighed 6·04 grm., and had a specific gravity of 7·825.

Its solution in hydrochloric acid, gave no indication of the presence of sulphur. The Rhabdite crystals, which in microscopic needle-points were quite abundant in the cold solution, gradually disappeared on the addition of nitric acid, leaving only a very minute quantity of a white granular powder, supposed to be silicate of magnesia. It amounted to only 0·001 per cent. The composition of the mass was,

Iron, - - - - - - - - -	97·900
Nickel, with traces of chromuim, cobalt, magnesium and phosphorus,	2·100

The phosphorus, as determined upon seven gram. of the peroxyd of iron precipitate, was less than eight parts in 10·000. No search was made for tin or copper.

As I have not yet been able to procure a polished slice of the iron, I can add nothing concerning the Widman figures. If they exist, they will be extremely fine, and probably resemble those of the Braunau iron.

Amherst, March 20, 1867.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the conversion of dynamical into electrical force without the aid of permanent magnetism.*—The magneto-electric machine of Mr. Wilde has been briefly described in a former notice. A modification of this apparatus which possesses much theoretic interest has been contrived by the brothers W. and C. W. Siemens, and at about the same time and independently by Wheatstone. In these machines the steel magnets of the generating or primary magneto-electric machine are replaced by electro-magnets. The electro-magnets are first charged by a galvanic battery or other rheomotor, the armature is then caused to rotate, and the battery is removed, when the magnetic action continues to accumulate without its aid. Instead of employing a battery the soft iron of the electro-magnet may be touched by a permanent magnet. In practice this is not necessary, as the residual magnetism of the iron is sufficient. In Wheatstone's apparatus the wires covering the electro-magnets and those surrounding the armature are connected, so that the current, which is made to move in one direction, acts upon the electro-magnet in such a manner as to increase its existing polarity. The force required to turn the armature then becomes vastly increased, as well as the intensity of induced current. In this case also the residual magnetism of the iron is the primary cause of the current which then goes on increasing up to a maximum, at the expense of course of a certain amount of work expended in producing rotation. When a cross wire is placed so as to divert a portion of the current from the electro-magnet a remarkable increase in the heating and magnetizing power of the current is observed. Wheatstone accounts for this increase by supposing that the current passing through the armature branch and cross wire experiences a much less resistance than if it had passed through the armature and electro-magnet branches, and though the electro-motive force is less, the resistance having been rendered less in a greater ratio, the resultant effect is greater. In conclusion Wheatstone points out the analogy between the augmentation of the power of a weak magnet by means of an inductive action produced by itself, and the accumulation of power shown in the electrical machines of Holtz and others, in which a very small quantity of electricity is made by a series of inductive actions to equal or exceed the effects of the most powerful machines of the ordinary construction. —*Proc. of the Royal Society*, xv, 367, 369. W. G.

2. *New applications of methods of reduction in organic chemistry.*—Berthelot has studied the action of iodhydric acid upon a variety of organic compounds, and has greatly extended our knowledge of the transformations produced by this valuable reagent, the introduction of which, it will be remembered, is due to himself. The experiments were conducted by introducing the organic matter to be operated on into a tube with a very concentrated solution of iodhydric acid, sealing the tube and heating to a temperature of 275° C. In this manner the iodid, bromid, and chlorid of ethylene yield hydruret of ethylene, haloid acid, and free iodine, the reaction in the case of the iodid being represented by the equation

$$C_4H_4I_2+2HI=C_4H_6+2I_2,$$

and in the case of the bromid of ethylene by the equation

$$C_4H_4Br_2+4HI=C_4H_6+2HBr+4I_2.$$

In like manner di-iodhydrate of acetylene, $C_4H_2(2HI)$, and iodid of ethyl, C_4H_5I, yield hydruret of ethylene and free iodine. Iodid of allyl yields hydruret of propylene, according to the equation

$$C_6H_5I+3HI=C_6H_8+2I_2.$$

Iodhydric acid acts even upon perchlorinated compounds; thus sesquichlorid of carbon, C_4Cl_6, reacts with it according to the equation

$$C_4Cl_6+12HI=C_4H_6+6HCl+6I_2.$$

All the hydrocarbons capable of uniting directly with iodhydric acid, as for instance all the ethylenes and acetenes, $C_{2n}H_{2n}$ and $C_{2n}H_{2n-2}$, first unite with iodhydric acid, and afterward by the action of an excess of the acid upon the new compound formed, yield a new hydrocarbon and free iodine.

Alcohols treated in the same manner yield first the iodids of the radicals and these then react with iodhydric acid in the manner explained above. Thus the first action of iodhydric acid upon common alcohol may be represented by the equation

$$C_4H_6O_2+4HI=C_4H_6+H_2O_2+2I_2,$$

iodid of ethyl being an intermediate product. In like manner glycerine yields hydruret of propylene.

Ethers derived from the oxacids are first decomposed with formation of an iodid of the radical and regeneration of the oxacid; the iodid and oxacid are then separately acted on by the excess of free iodhydric acid. Thus methyl-formic ether and iodhydric acid react according to the equation

$$C_2H_2(C_2H_2O_4)+2HI=C_2O_2+C_2H_4+H_2O_2+I_2.$$

Common aldehyd yields hydruret of ethylene mixed with hydrogen and probably with some marsh-gas. Acetone gives hydruret of propylene according to the equation

$$C_6H_6O_2+4HI=C_6H_8+H_2O_2+2I_2,$$

but the hydruret of propylene undergoes a partial decomposition, probably according to the equation

$$C_6H_8+H_2=C_4H_6+C_2H_4.$$

Organic acids treated with iodhydric acid are reduced to formenes containing the same quantity of carbon as the acid, provided that these are sufficiently stable to resist a temperature of 275° C. Thus acetic acid reacts according to the equation

$$C_4H_4O_4+6HI=C_4H_6+2H_2O_2+3I_2.$$

Succinic acid, like butyric acid, yields hydruret of butylene;

$$C_8H_6O_8+12HI=C_8H_{10}+4H_2O_2+6I_2.$$

The author remarks that the facts mentioned above furnish a general method of reproducing the fundamental hydrocarbon of each series by means of all the bodies in the series. Thus hydruret of ethylene, $C_4H_4(H_2)$, yields by replacement $C_4H_4(Cl_2)$, $C_4H_4(HI)$, $C_4H_4(H_2O_2)$, $C_4H_4(O_4)$, and $C_4H_2(O_4)(O_4)$, in each the substitution being

by equal volumes. All these compounds, by the reducing action of iodhydric acid, reproduce the original hydrocarbon, C_4H_6.—*Bull. de la Société Chimique*, Janvier, 1867, p. 53. W. G.

3. *On the monatomic nitriles.*—The monatomic nitriles may be regarded as primary monamines, the three atoms of hydrogen in ammonia being replaced by one atom of a triatomic radical. L. Henry has shown that this view is supported by several new and interesting facts. Thus acetonitrile, $(\mathrm{C}_2H_3)'''N$, readily unites with dry bromhydric and iodhydric acids with production of intense heat. The resulting salts are solid crystalline white bodies, soluble in alcohol but insoluble in ether. They are rapidly decomposed by water or moist air, forming acetic acid and salts of ammonia. Benzonitrile gives analogous compounds. Sulphocyanic acid and sulphocyanid of ethyl may also be referred to the type of ammonia, like the corresponding cyanic acid and cyanid of ethyl. The sulphocyanids of ethyl and allyl combine readily with dry bromhydric and iodhydric acids, giving white crystalline bodies decomposed by water.—*Bull. de la Soc. Chim.*, Janvier, 1867, p. 85. W. G.

4. *On graphitoid boron.*—Wöhler has obtained the so-called graphitoid boron, discovered by Deville and himself, in sufficient quantity for analysis, and has found that the substance in question is not boron but a compound of boron and aluminum. The compound is always formed in preparing crystallized boron or by fusing aluminum in the vapor of chlorid of boron. The borid crystallizes in very thin pale copper-colored six-sided tables which, according to Prof. W. H. Miller, are monoclinic. It does not burn in the air but burns in chlorine with brilliancy, forming chlorid of aluminum and chlorid of boron. Two analyses led to the formula AlB_2.—*Ann. der Chemie und Pharm.*, cxli, 268. W. G.

5. *On the constitution of mellitic acid.*—Bæyer and Scheibler have found that mellitic acid is six-basic and has the constitution of benzol, in which six atoms of hydrogen are replaced by six of carbonyl, $\mathrm{C}O_2H$, so that its formula is $\mathrm{C}_6(\mathrm{C}O_2H)_6$. When heated with lime it is completely decomposed into carbonic acid and benzol. With sodium amalgam mellitic acid takes up six atoms of hydrogen and forms the six-basic acid, $\mathrm{C}_6H_6(\mathrm{C}O_2H)_6$, which, when heated with sulphuric acid, yields a four-basic acid, $\mathrm{C}_6H_2(\mathrm{C}O_2H)_4$. This can take up four atoms of hydrogen to form a new acid, which, when treated with sulphuric acid, again loses carbonic acid. The final product of these transformations is benzoic acid. The authors beg chemists who may possess a stock of mellite to supply them with material for their investigation.—*Ann. der Chemie und Pharm.*, cxli, 271. W. G.

6. *On the cyanic ethers.*—Gal has studied the action of chlorhydric and bromhydric acids upon cyanic ether. The dry ether absorbs chlorhydric acid gas, and by distillation a liquid is obtained which has a penetrating smell, fumes slightly in the air, and boils between 108° and 112° C. The author gives to this body the formula $C_4H_5O.C_2NO.HCl$, which may be referred to the type of chlorid of ammonium, and written $N\left\{\begin{matrix} \overset{\text{II}}{C_2O_2} \\ C_4H_5 \\ H \end{matrix}\right\}Cl$. Water decomposes this substance, forming chlorid of

ethylammonium and carbonic acid, the reaction being expressed by the equation

$$C_4H_5O.C_2NO.HCl+2HO=C_4H_7N,HCl+2CO_2.$$

Bromhydric acid yields a similar compound boiling at 118°–122° C. Heated in sealed tubes at 100° both compounds yield cyanuric ether and free hydracid. The cyanic ether obtained by Cloëz by acting upon ethylate of sodium with chlorid of cyanogen, and which is a neutral liquid insoluble in water and not volatile, exhibits an entirely different behavior toward the hydracids. Chlorhydric acid converts it into cyanuric acid and chlorid of ethyl, the reaction being represented by the equation

$$3(C_2NO.C_4H_5O)+3HCl=C_6N_3O_3.3HO+3C_4H_5Cl.$$

Bromhydric acid acts in a similar manner. Gal is of opinion that the compound of Cloëz is the true cyanate of ethyl, $\left.\begin{matrix}C_4H_5\\C_2N\end{matrix}\right\}O_2$, while the cyanic ether of Wurtz is an ammonia, $N\left\{\begin{matrix}C_2O_2\\C_4H_5\end{matrix}\right.$. The author promises a further investigation of the subject. The connection of his results with those of L. Henry, mentioned above, will be obvious at a glance.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 435. W. G.

7. *On the action of alcohols upon terchlorid of phosphorus.*—When absolute alcohol is poured drop by drop into an equivalent quantity of terchlorid of phosphorus a powerful reaction ensues, the principal product of which is a body having the formula $P(Cu_2H_5O)Cl_2$, or oxethylchlorid of phosphorus. This is a liquid boiling at 117° C., heavier than water, and decomposed by this into alcohol and phosphorous acid. Butylic and amylic alcohols give analogous bodies.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 481. W. G.

8. *On the polymers of acetylene.*—Berthelot has studied the products of the action of heat upon acetylene, and has arrived at results of great interest and importance. When acetylene is heated to a temperature approaching that at which glass melts, it is gradually converted into a series of polymeric bodies, among which are benzol, styrol, reten, and fluorescing hydrocarbons. In one experiment Berthelot prepared pure acetylene by the direct combination of pure hydrogen and pure carbon, and then obtained from this acetylene benzol, which was thus formed by actual synthesis from its elements. The relation between the two substances is readily seen since $3C_4H_2=C_{12}H_6$; benzol is therefore triacetylene. Berthelot believes that a volatile hydrocarbon occurring among the products of the action of heat upon acetylene is diacetylene, $2C_4H_2=C_8H_4$. Styrol or tetracetylene, $4C_4H_2=C_{16}H_8$, forming about one-fifth of the entire product was easily recognized. Naphthalin forms another product, and probably is a product of the decomposition of pentacetylene, $C_{20}H_8=5C_4H_2-H_2$. The highest product yet examined is retene, which Berthelot regards as enneacetylene, $C_{36}H_{18}=9C_4H_2$.—*Ann. der Chem. und Pharm.*, cxli, 173. W. G.

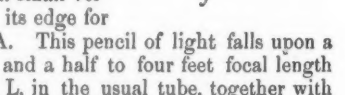
9. *New method for the preparation of oxygen.*—When cuprous chlorid Cu_2Cl_2 is exposed to the air, it absorbs oxygen and is converted into cuprous oxy-dichlorid Cu_2OCl_2. If this latter compound be heated to

about 400° C., it is decomposed into oxygen and cuprous chlorid, as before.

Upon this reaction Mallet founds a method for the commercial preparation of oxygen. The cuprous salt, mixed with sand or clay to prevent fusion, is placed in a retort, which can be rotated horizontally. It is readily oxydized by a current of air, passed over it for three or four hours. The heat necessary for the decomposition is no higher than that required for the preparation of oxygen from potassic chlorate. With this arrangement the loss of material is inappreciable. Each kilogram of cuprous chlorid yields 28 to 30 liters of oxygen.

A very simple modification of this method permits the preparation of chlorine gas with equal facility. If after oxydation chlorhydric acid gas be conducted over the cuprous oxy-dichlorid, the latter becomes cupric chlorid, $CuCl_2$. At a red heat, this salt decomposes into cuprous chlorid and chlorine.—*L'Institut*, 1867, p. 61.

10. *Apparatus for detecting differences of density in transparent media.* —Dr. A. Töpler has given a new method of observing certain important phenomena which escape attention by direct vision more or less completely. His pamphlet, "Beobachtungen nach einer neuen optischen Methode, Bonn, 1864," is not at hand; but from a very complete synopsis (with quarto plate) in Ergänzungsblätter zür Kenntniss der Gegenwart, Hildburghausen, 1866, i, 88, and from his article on the application of this method to microscopic observations, in Pogg. Ann., 1866, cxxvii, 556–580, we give the following:



Let A be a radiant; a good lamp surrounded with a brass cylinder. The latter has a circular opening, in front of which is placed a small vertical metallic screen with holes near its edge for the transmission of the light from A. This pencil of light falls upon a system of lenses, L, of at least two and a half to four feet focal length and of large diameter. The lenses, L, in the usual tube, together with the lamp, A, and screen, are supported on the same table; the screen can be moved in the axis of the lens, L, to change the divergence of the pencil. At a distance of from ten to twenty-five feet, L will give the image B of A. Here a small astronomical telescope, T, is so placed in the common axis that this image falls just on the front face of the objective; at this point is placed a metallic screen, *s*, having a straight, sharp edge; this screen can be moved by a screw, like the movable part in the slide of Bunsen's spectroscope. This is the "Schlieren"-apparatus, which hence may be put together in almost any philosophical cabinet.

If the lens, L, is perfect, the entire beam of light is concentrated in B; and in moving the screen, *s*, down, no change in the image, B, is observed until the screen reaches B, when the lens, L, *suddenly* disappears. But if L is not perfect, if it contains a flaw, *f* (i. e., *Schliere*), then this will refract light differently from the body of the lens; the rays from *f* will *not* collect in B; when *s* has nearly reached B, many of the rays from *f* (which otherwise would have reached the objective of T and thus the eye) are now cut off; hence *f appears dark on the bright ground* of the image of L. And when *s* is moved down so as completely to cut off the regular image B, many of the rays from *f* will yet reach the ob-

jective, so that *f now appears bright upon a dark ground.* As the distance LT is quite considerable (even twenty feet or more), and as the telescope may have considerable power, this method is *incredibly sensitive.* The object to be examined must of course be transparent; if it is the objective of a telescope, this serves as L; if a flame or the like, it is placed at M near L, between L and T.

Töpler has found that perfectly homogeneous glass is exceedingly rare; it has usually either filiform flaws (which are easily detected and but little injurious) or has flaws throughout its entire mass, appearing in this apparatus as if brushed over by a brush. These very injurious flaws hitherto were not discovered till the lens was almost worked out; by this apparatus they are easily detected in the glass.

The *flame* of a Bunsen burner (placed at M) shows besides the three well known parts visible to the unaided eye, two others: an exterior, large, very well defined cone (consisting of the heated products of combustion and of air) and a bright interior cone, resting on the tube as the base, having a sharp outline (consisting of the gas mixture before any combustion has taken place).

The *electric spark,* when produced by the induction coil and allowed to pass between the electrodes held at M, shows very interesting and instructive phenomena; of which, however, it would be very difficult to give a clear idea in a few words.

The *sound-wave in air* corresponding to each separate spark is, like the sound, a *single impulse;* it is beautifully visible as a *bright circle or ellipse* around the source of sound, moving regularly from the center outward. A succession of sparks in regular intervals gives moving circles of light. The spark from a Leyden jar gives a sharp sound, and one increasing circle of light one sound-wave. That this is a sound-wave, Töpler proved by trying in vain to blow it aside by a feeble current of air, and also by finding it to progress more rapidly in heated air. But more interesting yet is his experiment on the reflected sound-wave. Suspending a glass plate from the brass electrodes by means of corks, he saw in lines of light precisely the same phenomenon which we observed when circular waves of a liquid meet a plane wall: they are reflected as circles described from a point as far behind the obstacle as the origin of the wave is in front of the same. By having the electrodes either in the axis of the apparatus or at right angles to it, Töpler found that in the first case the lines were elliptical, in the latter circular: so that the wave is a surface of revolution around the electrodes as an axis.

It may well be said that by means of Töpler's apparatus we *see the sound;* in Chladni's and even in Kundt's experiments we only see the motion imparted by air to some other body, not the motion of the air itself. For the application of this method to the microscope, see Töpler's article in Pogg. Ann. G. H.

11. *On atomic heat and the specific gravity of gases.*—Gustav Schmidt, known by his theoretical labors on heat and the steam-engine,* has published an article on "*Atom-wärme*" (the specific heat of atoms, which we abbreviate as above); but only the appendix to the article, treating on the specific gravity of gases, seems to contain any addition to our knowledge.

* Theorie der Dampfmaschinen. Freiberg, 1861.

The atomic heat, w, of an element ($=gc$, where g is the atomic weight and c the specific heat of the substance), he endeavors to prove to be $w=an$, where a is a constant, the same for all the elements, and n the characteristic of the element. Therefore, if α represents the number of atoms in any compound, and if the atomic heat of the compound equals the *sum* of the atomic heat of the several atoms, it follows that

$$w=gc=\Sigma\alpha\,.\,an=a\Sigma\alpha n.$$

Schmidt makes a number of suppositions in regard to a and hence obtains different values of n. For *solids* he takes either $a=\frac{32}{30}=1{\cdot}0666$ or $a=0{\cdot}8$; for gases he adopts $a=0{\cdot}86$, and correspondingly for n.

	Solids.		Gases.
n	$a=1{\cdot}0666$	$a=0{\cdot}8$	$a=0{\cdot}86$
2	H, C, B, Si	C	H
3	P	H, B, Si	
4	F, O	.....	O, C, N, S
5	N, S	O, P	Br, Cl
6	Cl, Br, I, and metals	F	P, Si
7		N, S	
8		Cl, Br, I, and metals	As, Sn, Ti

A glance at this table is enough to convince any one that this supposition cannot be correct. We need only to calculate the values $w=an$ from this table, and compare them with those used by Kopp, to see that the so-called "*characteristic*" is essentially characterized by having no character whatever.

We should not have referred to this memoir if we had not found the closing pages thereof to contain a most accurate theoretical determination of the *specific gravity* δ of all permanent gases, and of vapors above their boiling points (that of atmospheric air $=1$). If g be the *weight of a molecule* of equal volume with HCl or NH_4, he finds $\delta=0{\cdot}0346832\,g$, with a possible error in the coëfficient of less than one-fifth per cent, and *an actual error of less than one-fiftieth per cent.* To find this very important number he makes use of a relation from the mechanical theory of heat and the following quantities from experiments: pressure of atmosphere, specific gravity of air, coëfficient of expansion of air, and the percentage composition of the atmosphere with $O_2=32$ and $N_2=28$: all fundamental quantities determined by Regnault and others with most scrupulous care; by adopting the specific gravity of oxygen as determined by Regnault (1·10563) the atmosphere would contain 23·57 instead of 20·81 per cent of oxygen. This shows that the calculated density of oxygen (1·1099) is much more reliable than the observed one.

He finds furthermore, the *mechanical equivalent of heat* $k=422{\cdot}06$ meterkilograms (for kilogram-Centigrade) instead of Joule's, 423·54, $A=\frac{1}{k}$; the specific heat of aqueous vapor $=H_2O$ 0·3822. As a further consequence from an empirical relation, $g(C'-C)=2$, (where C' specific heat by constant pressure, C rational specific heat) he finds finally the Gay-Lussac Mariotte's law expressible in $\frac{ApV}{T}=2$; or, *by heating a*

molecule of volume, V, *of any gas under any constant pressure*, *p*, *at any temperature*, T ($T_0=\frac{1}{\alpha}=273°$ C. below 0° C.) *two calorics* (or units of heat) *are necessary to overcome the external work for each degree C. the temperature is raised.* The molecular weight and the unit of heat must of course refer to the same unit of weight.—*Sitzungsberichte*, Wien, 1865, lii, 417–452; *Corresp. Blatt d. naturf. Vereins*, Riga, 1864, xiv, 35–44; *L'Institut*, 1866, p. 191. G. H.

12. *Expansion of water below 4° C.*—Dr. Weidner has, by means of water thermometers (bulb a cylinder 11mm. diameter, 100mm. high, tube not less than 1mm.), determined this expansion with great care, starting in four independent series, with four different water-thermometers from the temperature of 4° C. to 0° C. and then to −9° or −10° C. From each series he calculates by a formula of form $V=1+at+bt^2+ct^3$ the expansion for each degree C., the volume at +4° C. being unity.

By comparing the four series I find a very close correspondence except for −4° C., where the first series deviates 37 millionths; on referring to the formula, the stated value, 513 millionths, is found to be 550·6, agreeing with the other three in the sixth decimal. Taking the mean from the four values given by Weidner we obtain the following volumes of water.

	Weidner.	Despretz.	Pierre.
+ 4° C.	1·000000	1·000000	1·000000
+ 3 "	14	8	5
+ 2 "	40	33	27
+ 1 "	80	73	63
0 "	137	127	118
− 1 "	210	214	214
− 2 "	302	308	317
− 3 "	415	422	430
− 4 "	550	562	556
− 5 "	709	699	700
− 6 "	893	918	865
− 7 "	1104	1135	1054
− 8 "	1344	1373	1271
− 9 "	1608	1631	1520
−10 "	1·001905		1803

Above zero Weidner's volumes are greater; but between 0° and −6° C. the three experimenters correspond well enough.—*Pogg. Ann.*, 1866, xxix, 300–308. G. H.

13. *Specific heat of soils.*—L. Pfaundler has determined the specific heat of seventeen soils with great care. The accuracy of the method with a modified Regnault's apparatus, was proved by determining the specific heat of water and of *Iceland spar*. The first showed the same increase as found by Regnault; the second gave, by ten independent determinations on the same piece, successively more and more subdivided, 0·20588, with a probable error of only 0·00006. This agrees with Regnault's results, 0·20694 (from eighteen determinations), and Kopp's, 0·206 (from four determinations), thus disproving that of Pape and Neumann (0·202). For *soils* he finds the specific heat between *one-fifth* and *one-half* (0·1923 and 0·5069); the most common value is 0·25 to 0·30.

Soils free from humus have the lowest specific heat, whether they con-

sist of sand or lime; this might have been concluded from the fact that calcite and quartz have almost the same specific heat, viz., 0·20 and 0·19. The more rich a soil in humus, the higher is its specific heat. Thus peat was found to have 0·507, and a soil, very rich in humus, from Kaiserstein, gave 0·4143. Since water also must increase the specific heat of a soil, we may conclude that loamy soils also have a high specific heat.

So great a variation in so important a physical property of soils is of considerable importance to agriculture. A plant sensitive to changes in temperature may be unable to grow on soils of low specific heat, however excellent this soil might be in other respects.—*Pogg. Ann.*, 1866, cxxix, 102–135. G. H.

14. *The spectrum of the electrical brush and glow* has been observed by A. Schimkow. While the spectrum of the spark is affected by and produced in both nitrogen and oxygen, the *brush* discharge only gives *nitrogen* lines, and is not formed at all in pure oxygen; a trace of nitrogen entering the tube is sufficient to reproduce the light and its peculiar lines. The same is true in regard to the luminous glow observed when electricity is discharged between two points. At the same time the latter spectrum is still much fainter than that of the brush. It is characteristic of these lines that they especially occur in the most refrangible part of the spectrum. This seems due to the *much lower temperature* in the brush and glow discharge, as compared to the discharge in a spark. By introducing in the circuit of a coil a wet string four meters long, Schimkow made the nitrogen spectrum of a Geissler-tube appear precisely like the brush spectrum: the yellow lines had been weakened much more than the violet ones; at a low temperature, therefore, nitrogen seems especially to emit the most refrangible rays, harmonizing with the observation of von Waltenhofen, according to which the least refrangible rays are first extinguished when air is successively more and more rarefied. Thus the *brush* and *glow* are due to the luminosity of nitrogen at a temperature below that at which oxygen becomes luminous; and furthermore they consist principally of the more refrangible rays.—*Pogg. Ann.*, 1866, cxxix, 508–520; *L'Institut*, 1867, p. 55. G. H.

II. MINERALOGY AND GEOLOGY.

1. *Note on a new genus of fossil Crustacea;* by F. B. Meek.—In the last number of this Journal, p. 257, I mentioned having seen in "The Reader," a notice of a paper by Mr. Henry Woodward, read before the Geological Society of London, in which he proposed to establish a new genus *Prestwichia*, for the reception of some of the species generally referred to *Belinurus*, but differing from the types of that genus in having the body segments anchylosed. The abstract of Mr. Woodward's paper, mentioned by me, was unaccompanied by figures or diagnosis, and no particular species were cited, but the fact that our Illinois fossil has its body segments anchylosed, and agrees very nearly in its general appearance with a part of the species referred by English authors to *Belinurus*, led me to refer it to the new genus *Prestwichia*. Since that time, I have seen Mr. Woodward's interesting paper as published in the Quarterly Journal of the Geological Society, vol. xxiii, No. 89, p. 28, with ex-

cellent figures, both of the typical *Belinurus* and the new genus *Prestwichia*. From these figures and the accompanying remarks, it becomes evident that certain differences between the previously published figures of the type upon which the genus *Prestwichia* is founded and our Illinois fossil, and which were noticed by us in the remarks accompanying the description of the Illinois species as being probably of more than specific importance, if not due to some accidental imperfection of the specimens figured by Prestwich, really exist, and consequently forbid the reference of our species to this new genus. As it also differs upon quite as important characters from the genus *Belinurus*, as now restricted and clearly illustrated by Mr. Woodward, it becomes necessary to propose for its reception a third genus, holding a somewhat intermediate position between *Belinurus* and *Prestwichia*.

For this new genus I would propose the name *Euproops*, in allusion to the anterior position of its eyes. This form is at once distinguished from the restricted genus *Belinurus*, by its anchylosed abdominal segments, and the anterior position of its eyes, as well as by the more oval or subcircular outline of its abdomen. From *Prestwichia*, with which it more nearly agrees in general form, as well as in its anchylosed segments, it differs remarkably in having the area enclosed by its eye-ridge (glabella) comparatively small, and of a quadrangular form, with the eyes situated far forward at its anterior lateral angles. On comparing these characters of the central region of its head with the corresponding parts of *Prestwichia*, as illustrated by Mr. Woodward, it will be seen that the latter differs in having the glabella proportionately much larger, and transversely elliptic in outline, with the eyes widely separated and placed far back at its lateral extremities. It also has within this large elliptic area a smaller crown-shaped one not seen in *Euproops*, but corresponding in size and general appearance with that bearing the eyes at its anterior lateral angles in the latter type.

March 29th, 1867.

2. *Geological Survey of Illinois*, A. H. Worthen, Director. Volume II, *Paleontology*, xix, and 470 pp., royal 8vo, with 50 plates and 30 wood-cuts. Springfield, 1866. Published by authority of the Legislature of Illinois.—This important and beautifully illustrated work, consists, besides the Introduction, of three Sections, as follows:

Section I.—"Descriptions of new species of Vertebrates, mainly from the Subcarboniferous limestones and Coal Measures. By J. S. Newberry and A. H. Worthen.

"Remarks on the occurrence of Fossil Fishes in Illinois. By A. H. Worthen.

"Supplement to descriptions of Vertebrates, consisting of a description of a new genus, and species of Reptiles from the Coal-measures. By Prof. Edw. D. Cope.

Section II.—"Descriptions of Invertebrates from the Carboniferous system. By F. B. Meek and A. H. Worthen.

"Supplement to the descriptions of Invertebrates, consisting of the descriptions of Polyzoa from the Paleozoic rocks. By H. A. Prout, M.D.

Section III.—"Report on the Fossil Plants of Illinois. By Leo Lesquereux."

From the Introduction we learn that:

"The number of species of all kinds, illustrated and described, in the Report, is about 325, of which nearly 300 were discovered or first made known to science through the agency of the Illinois Geological Survey. Of these 325 species, 50 are plants, 156 invertebrate animals, and 119 vertebrates. Altogether they represent 115 genera, 25 of which have been established by parties connected with the survey. Of these genera 18 are plants, 67 invertebrates, and 30 vertebrates—the latter of which, with one exception (a *Batrachian*), being all fishes. Of the 115 genera represented, 81 are more or less fully characterized, and most of them illustrated in this volume."

From the cursory examination we have been enabled to make, we find many important additions to our knowledge of American Paleontology in this volume. At present we can only notice a few of them.

Mr. Worthen states that the fossil fishes abound in four horizons—usually limited to a single stratum, rarely more than a few inches in thickness. In the beds which form the base of the Carboniferous system in Illinois, these remains are comparatively rare; but in the upper strata they become exceedingly abundant. The lowest bed occurs in the upper part of the Burlington limestone. It is a stratum of brownish-gray rock, from four to six inches thick, in which the teeth and spines of fishes are imbedded in great numbers. It was first observed at Quincy, Illinois, but was afterwards identified on Honey creek in Henderson county and at Augusta in Iowa, nearly one hundred miles away from the first named locality. The second *fish bed* occurs fifty or sixty feet higher, in the series near the base of the quarry rock of the Keokuk group. The third, in ascending order, is found in the upper part of the Keokuk limestone. The fourth is situated at the junction of the lower limestone in the Chester group with the green shales above. All these beds belong to the Mountain limestone or Subcarboniferous period. In the Coal-measures, the remains of fishes again become more rare, in Illinois. "Of the 118 species, described and illustrated in this volume, 16 are from the Coal-measures, 17 from the Chester limestone, 18 from the St. Louis limestone, 49 from the Keokuk limestone, 14 from the Burlington limestone; 3 from the Kinderhook group, and 1 from Devonian Strata," (p. 16). This is the first memoir in which any large number of the paleozoic fishes of America have been described; and as the species are well figured it will constitute the foundation on which all subsequent investigations in this department must be conducted. Next follows an interesting description of a new fossil *Batrachian*, discovered by Mr. Joseph Even, near Morris, Grundy county, Illinois, in a bed near the base of the Coal-measures.

In Section II will be found a great deal of information bearing on the classification of the Crinoidea; especially as regards such genera as *Actinocrinus*, *Cyathocrinus* and *Poteriocrinus* the relations of which are here discussed at length. The new genus *Strotocrinus* (M. & W.) has the formula of *Actinocrinus* in the lower part of the body, but is distinguished by the remarkable structure of the upper portion, which is greatly expanded and forms a ten rayed horizontal disc, the plane of which is at right angles to the vertical axis. The interior of *S. regalis*,

and some other species is provided with a peculiar, convoluted internal plate, resembling a shell of a *Bulla* or *Scophander*, placed with its longer axis so as to coincide with that of the body of the crinoid. This is illustrated by a wood-cut on p. 191.

The genus *Steganocrinus* has also the structure of *Actinocrinus* in the lower part, but with: "Rays, from the third primary radial pieces, forming greatly produced, free arm-like appendages, either bifurcating or simple, which are covered their entire length above by small plates, and provided on each side with a row of alternating true arms. Vault with a subcentral proboscis." These arm-like appendages are tubular, with the ambulacral orifices arranged along the sides,—opening out into the grooves of the true arms.

On page 220 there are some figures illustrating the wonderful structure of the vault of *Gilbertsocrinus*. It is there shown that this genus is identical with *Trematocrinus* (Hall), *Goniasteroidocrinus* (Lyon and Casseday), *Rhodocrinus* (Miller) pars, (as understood by some naturalists), and *Ollacrinus* (Cumberland). This latter name has priority over all others, but its author did not characterize the genus. The vault exhibits fine slender lobes, which are branched at their extremities. These have been mistaken lately for arms,* but M. and W. have shown that the true arms are situated in the re-entering angles between them. There are numerous important improvements in the classification of paleozoic genera of Echinodermata suggested in this work, which can only be understood by consulting the very instructive observations and figures.

An interesting fossil belonging to the *Xiphorura* is doubtfully placed in the genus *Bellinurus*, but Mr. Meek has informed us that he now considers it distinct from that genus and also from *Prestwichia* to which he afterwards thought it might be referable (this vol. ante, p. 257). As it will be noticed elsewhere in this Journal, we need not allude to it further here. We may be permitted, however, to remark on the affinities of the *Xiphorura* and the *Eurypterida* that the beautiful specimens of *Eurypterus* figured by Nieskowski in the "Archiv fur die Naturkunde Livland, &c.," 1859, have the six anterior segments of the body sculptured as in *Pterigotus;* but the posterior six are not so marked, unless indeed obscurely along the median line. These latter six have their posterior angles produced backward, to form short angular spines similar to those in the lateral margins of the abdomen of *Limulus*. If then we examine the inner surface of the cephalo-thorax of *Limulus*, we shall find there, indications of six or seven anchylosed segments, all with the scale-like sculpture of *Pterygotus*. These markings are not seen on the outside, and, though the character at first sight may not seem important, yet it will strongly impress many observers with the idea that we have buried, as it were, in the buckler of *Limulus* the anterior segments of *Eurypterus*. The species figured by Nieskowski is clearly not *E. remipes* as he supposes.

Mr. Lesquereux gives, p. 463, a table of the number of species of plants mentioned in his Report. The following are the general results:

* John Rofe, Esq., F.G.S., has figured (Geological Magazine, vol. ii. pl. 8) an English specimen with portions of these appendages which he maintains to be the remains of the arms. They are evidently, however, merely projecting lobes of the body, the formations of which are not yet understood.

1.	Whole number of species in Illinois,	120
2.	Number of new species in Illinois,	37
3.	Species found in Illinois not published before,	60
4.	Species in the catalogue not found in Illinois,	219
5.	Whole number in the catalogue,	280
6.	New species in the same,	146

This Report was drawn up in 1860; since then, other species have been collected, which will be described in future publications of the Survey.

The two volumes of the Geology of Illinois, which have been issued, establish for at least one Scientific Institution of that noble State, a very high character. The Paleontology is a first class work, equal to the best that has been published by any geological survey, and where the fossils are well worked out in a country, we may be sure that the physical structure is also correctly understood.

The principle, that every nation should contribute something toward the general advancement of knowledge (not merely by the dissemination of what was previously known, but by assisting in the discovery of those truths which, although existing in nature, have remained unknown to man from the beginning), is now recognized by all enlightened communities to be a sound one. The people of the State of Illinois have made an effort in that direction which, under the wise management of their able State geologist, has been highly successful, and creditable to all the parties concerned. E. B.

3. *On the occurrence of Eozoon in the Primary Rocks of Eastern Bavaria;* by Prof. GUMBEL. (Ber. Ak. München, 1866; Q. J. Geol. Soc., xxii, 23.)—A new species of *Eozoon*, the *Eozoon Bavaricum*, has been discovered by Prof. Gümbel in a rock consisting of a granular aggregation of calcite, serpentine, and a white hornblendic mineral, supposed to be of Huronian or Cambrian age. The specimens examined were from near Wunseidel and Thiersheim, and between Hohenberg and the Steinberg, especially the last-named locality. It exhibits—(1.) A thin band almost entirely calcareous, and traversed by a network of straight lines, or, when treated with acid, divided by band-like ribs into irregular cell-like spaces, the calcite filling which is seen to be granular. (2.) Thicker calcareous portions abounding in tufts of fine tubes, exactly as in *Eozoon;* these tubes end at the serpentinous portions (3.), which have generally the same form as in the *Eozoon* from Steinhag before described, but are much smaller. In decalcified examples they may be seen to possess the same vaulted margins as *Eozoon;* their breadth averages ·1 mm. and the diameter of the tubes ·01 mm. Generally these serpentine bands pass into an adjoining portion (4.), of one-half the width, or less, made up of very much twisted lamellæ, consisting of serpentine or a whitish mineral, and possessing highly vaulted and deeply channelled outlines. Prof. Gümbel considers that on the whole these characters undoubtedly prove the affinity of this more recent and very much smaller form to the group *Eozoon;* but as the last-mentioned structure (4.) differs from what has been observed in *Eozoon Canadense*, he gives it the distinctive name of *Eozoon Bavaricum*. Prof. Gümbell makes out, with more or less probability, that the *Eozoon* occurs in the pargasite of Pargas, Finland, the Coccolite-limestone of New York, at Tunaberg, Boden in Saxony, and Hodrisch in Hungary.

4. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in the hope that it may be of service to geologists.[1]

PART II.—STATES AND TERRITORIES WEST OF THE MISSISSIPPI RIVER AND BRITISH PROVINCES.

MINNESOTA.

1866. *Henry H. Eames*, 1st Ann. Rep., Saint Paul, 8vo, 23 pp.
" *Charles Whittlesey*, Rep. on Mineral Regions, Cleveland, 8vo, 54 pp.

IOWA.

1858. *J. Hall* and *J. D. Whitney*, Final Rep., vol. I, Albany, 8vo, 724 pp., 29 pl., 2 sect., map.
1859. *J. Hall* and *J. D. Whitney*, Suppl., vol. I, Albany, 8vo, 4 pp.
1860. " " " 8vo, 94 pp., 3 plates.
1860. " " Ann. Rep., Des Moines, 8vo, 75 pp.
1861.* *J. Hall*, Prelim. Notice of New Crinoidea, Albany, 8vo, 18 pp.
1867. *C. A. White*, 1st Ann. Rep., Des Moines, 8vo, 4 pp.

IOWA, WISCONSIN AND ILLINOIS.

1844. *D. D. Owen*, Rep. to Treas. Dept., Washington, 8vo, 191 pp., 16 pl., 4 maps.

WISCONSIN AND IOWA.

1848. *D. D. Owen*, Rep. on Chippewa Land Dist., Washington, 8vo, 134 pp., 23 pl., 14 sect., maps.

WISCONSIN, IOWA AND MINNESOTA.

1852. *D. D. Owen*, Final Rep. (U. S.), Philadelphia, 4to, 638 pp., 27 pl., 16 sect., map.

MISSOURI.

1855. *G. C. Swallow*, 1st and 2d Ann. Rep., Jefferson City, 8vo, 207, and 238 pp., 32 pl., 5 maps.
1857.* *G. C. Swallow*, 3d Ann. Rep., —— "
1859.* " 4th " " Jefferson City, 8vo, 14 pp.
1861.* " 5th " " " " " "
" " Geol. Rep. on S. W. Branch Pacific R. R., St. Louis, 8vo, 93 pp., map.

KANSAS.

1866. *Benj. F. Mudge*, 1st Ann. Rep., Lawrence, 8vo, 56 pp.
" *G. C. Swallow*, Prelim. Rep, Lawrence, 8vo, 198 pp.

ARKANSAS.

1858. *D. D. Owen*, 1st Rep., Little Rock, 8vo, 256 pp.
1860. " 2d " Philadelphia, 8vo, 433 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

LOUISIANA.

1853. *Randolph B. Marcy*, Rep. to War Dept. on Red River of La., (Geology by E. Hitchcock and G. G. Shumard; Paleontology, by B. F. Shumard,) 8vo, 320 pp., 66 sect. and plates.

TEXAS.

1859. *B. F. Shumard*, 1st Ann. Rep., Austin, 12mo, 17 pp.

ROCKY MOUNTAIN REGION.

1809. *M. Lewis* and *W. Clark*, Expedition across American Continent in 1804–6, by order United States Government, Philadelphia, 8vo, 2 vols. (London, 4to, 1814, and 8vo, 3 vols. 1817), maps.

1810.* *Z. M. Pike*, Expedition in western Territories in 1805–7, by order U. S. Government, Philadelphia, 8vo, maps, (London, 4to, 1811).

1823.* *Stephen H. Long*, Expedition from Pittsburg to Rocky Mts., in 1819–20, (War Dept.) (Compiled by Edwin James,) Philadelphia, 8vo, 2 vols. 503, and 442 pp. Atlas, (London, 8vo, 3 vols. 1823).

1824.* *S. H. Long*, Exped. to source of St. Peters River, in 1823, (War Dept.) (Geology by Wm. H. Keating,) Philadelphia, 8vo, 2 vols., maps, (London, 8vo, 2 vols. 1825).

1835. *G. W. Featherstonhaugh*, Rep. on Elevated Country between Missouri and Red Rivers, Washington, 12mo, 97 pp.

1836. *G. W. Featherstonhaugh*, Rep. on Geol. Reconn., *via* Wisconsin, to Cotean de Prairie, Washington, 12mo, 168 pp.

1843. *I. N. Nicollet*, Rep. to illustrate Map of Hydrographical Basin of Mississippi River, Washington, 8vo, 170 pp.

1845. *John C. Fremont*, Exped. to Rocky Mts. in 1852–4, (War Dept.), (Paleontology by James Hall), Washington, 8vo, 693 pp.

1848. *W. H. Emory*, Exped. from Fort Leavenworth to California, (War Dept.), includes Reports of J. W. Albert, P. S. Cooke, and A. R. Johnson, (Paleontology by J. W. Bailey), Washington, 8vo, 614 pp., maps.

" *A. Wislizenus*, Rep. of tour to North Mexico in 1846–7, with Col. Doniphan's Expd., Washington, 8vo, 141 pp., maps.

1852. *Howard Stansbury*, Exped. to Great Salt Lake, (War Dept.), (Geology and Paleontology by James Hall,) Washington and Philadelphia, 8vo, 487 pp., maps.

1853. *L. Sitgreaves*, Exped. down Zuni and Colorado Rivers, (War Dept.), Washington, 8vo.

1856. *G. K. Warren*, Exped. to Rocky Mts. in 1855, (Geology by F. V. Hayden), Washington, 8vo.

1857. *W. H. Emory*, Rep. on U. S. and Mexican Boundary Survey, vol. I, (Geology by C. C. Parry, A. Schott, W. H. Emory, and James Hall; Paleontology by James Hall and T. A. Conrad), Washington, 4to, 21 plates.

1859. *W. H. Emory*, Rep. on U. S. and Mex. Boundary, vol. II, Botany and Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific Railroad Exploration*, (War Dept.), vol. I, (Geology by George Gibbs), Washington, 4to.

1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. II, (Geology by James Schiel and Wm. P. Blake; Paleontology by J. Schiel J. W. Bailey, and W. P. Blake). Washington, 4to, plates.

1856. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. III, (Geology, by W. P. Blake, and Jules Marcou; Paleontology by James Hall,) Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IV, Botany; no Geology, Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. V, (Geology by W. P. Blake; Paleontology by L. Agassiz, T. A. Conrad, J. W. Bailey, and Geo. C. Schäffer,) Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VI, (Geology by J. S. Newberry; Paleontology by T. A. Conrad), Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VII, (Geology by Thos. Antisell; Paleontology by T. A. Conrad), Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VIII, Zoology; no Geology, Washington, 4to, plates.

1858. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IX, Zoology; no Geology, Washington, 4to, plates.

1859. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. X, Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XI, Literature of Surveys, and maps; no Geology, Washington, 4to.

1860. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XII, Parts I and II, Botany and Zoology; no Geology, Washington, 4to, plates.

1862. *F. V. Hayden*, Rep. on Geology of Upper Missouri Region, Philadelphia, 4to, 218 pp., map.

1865. *F. B. Meek* and *F. V. Hayden*, Rep. on Paleontology of the Upper Missouri, Part I, (Smithsonian Cont.) Washington, 4to, 135 pp., 5 plates.

PACIFIC COAST REGION.

Oregon and Northern California.

1848. *J. C. Fremont*, Rep. upon Upper California, Washington, 8vo.

1850. *James D. Dana*, Rep. on Geology of U. S. Explor. Exped., in 1838–42, New York, 4to. Atlas.

1850. *P. T. Tyson* and others, Reps. to War Dept., Washington, 8vo, 128 and 37 pp., 12 maps and sections.

1854. *Wm. P. Blake*, Rep. to War Dept., Washington, 8vo, 80 pp.

California.

1853. *John B. Trask*, 1st Ann. Rep. Geol. Sierra Nevada, ——?, 8vo, 31 pp.

1854. *J. B. Trask*, 2d Ann. Rep. Geol. Coast Mts. and part of S. Nevada, ——?, 8vo, 95 pp.

1855. *J. B. Trask*, 3d Ann. Rep. Geol. Coast Mts., Sacramento, 8vo, 93 pp.

1856. *J. B. Trask*, 4th Ann. Rep. Northern and Southern Cal., Sacramento, 8vo, 66 pp.
1855. *W. P. Blake*, Rep. to Coast Survey on Geology of Cal., Washington, 22 pp., 4to.
1861. *Josiah D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 50 pp.
1862. *J. D. Whitney*, Letter to Governor (Rep. of Progress), San Francisco, 8vo, 7 pp.
1862.* *J. D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 33 pp.
1863. *J. D. Whitney*, 2nd Ann. Rep., San Francisco, 8vo, 12 pp.
1864. *J. D. Whitney*, Rep. Paleontology, vol. I, Philadelphia, 8vo, 243 pp., 32 pl. (Carboniferous and Jurassic Fossils by F. B. Meek; Triassic and Cretaceous, by W. M. Gabb.)
1865. *J. D. Whitney*, Rep. Geology, vol. I, Philadelphia, 8vo, 498 pp., 10 plates.
1866. *J. D. Whitney*, Rep. Paleontology, vol. II, part I, Philadelphia, 8vo, 38 pp. (Tertiary Invertebrate Fossils by W. M. Gabb.)
1866. *J. D. Whitney*, Letter to Governor on Survey, San Francisco, 8vo, 14 pp.

CALIFORNIA AND ARIZONA.

1861. *Joseph C. Ives*, Rep. on Colorado River, Washington, 4to, plates, (Geology and Paleontology by J. S. Newberry.)

BRITISH PROVINCES.

NEWFOUNDLAND.

1839.* *J. B. Jukes*, Prelim. Rep. (Legislative Doc.), folio, St. Johns.
1842.* " General Rep. in Author's "Excursions in and about Newfoundland," London, 12mo, 2 vols. (Separate, with sections, London, 12mo, 160 pp. 1843.)

NOVA SCOTIA.

1846.* *J. W. Dawson*, Rep. on Coal-fields of Caribou Cove, &c. (Legis. Doc.) Halifax, folio.
1860. *Joseph Howe, and Henry How*, Rep. on Discovery of Gold in Nova Scotia, (Legis. Doc.) Halifax, folio, 4 pp.
1861. *J. Howe*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 7 pp.
1862. *Henry Poole*, Rep. on Gold-fields, Western Section. (Appendix on Minerals, by H. How.) (Legis. Doc.) Halifax, folio, 25 pp.
1862. *J. Campbell*, Rep. on Gold-fields, Eastern Section. (Legis. Doc.) Halifax, folio, 8 pp.
1863. *J. Campbell*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 12 pp.
1864* *David Honeyman*, Rep. on Geol. Survey of Nova Scotia, and Cape Breton. (Appendix on Minerals by H. How.) (Legis. Doc.) Halifax, folio, 7 pp.
1865. *H. How*, Rep. on Minerals collected by D. Honeyman. (Legis. Doc.) Halifax, folio, 4 pp.

NEW BRUNSWICK.

1839. *Abraham Gesner*, 1st Ann. Rep., St. John, 8vo, 87 pp.
1840.* " " 2d " " " ——
1841.* " " 3d " " " 88 pp.
1842. " " 4th " " " 101 pp.
1843. " " Rep., with account of Public Lands, St. John, 8vo.
1850.* *J. Robb*, in Johnston's Agricultural Rep., Frederickton, 8vo, map.
1865. *L. W. Bailey*, Rep. on Southern N. Br., Frederickton, 8vo, 159 pp., map, section.
" *Henry Y. Hind*, Rep., especially on the Quebec Group, Frederickton, 8vo, 293 pp.

CANADA.

1845. *Wm. E. Logan*, 1st Rep. (for 1843), Montreal, 12mo, 159 pp.
1846.* " Rep. (for 1844,) " " 110 pp.
1847.* " " (for 1845), " " 125 pp.
" * " " (for 1846), " " 66 pp.
" * " 2 Repts. on Mining Region of Lake Superior, Montreal, 12mo, 31 pp.
1849.* *W. E. Logan*, Rep. (for 1847), Montreal? 12mo, 165 pp.
1849.* " Rep. on N. shore Lake Huron, Montreal, 12mo, 51 pp.
1850. " Rep. Progress for 1848, Toronto, 12mo, 65 pp.
" " " " 1849, " " 115 pp.
1852. " " " 1850, Quebec, " 54 pp.
" " " " 1851, " " 131 pp.
1854. " " " 1852, " " 179 pp.
1857. " " " 1853–6, Toronto, 12mo, 494 pp. Atlas, 4to, 22 pl.
1858. *W. E. Logan*, Rep. Progress for 1857, Toronto, 12mo, 240 pp.
1859. " " " 1858, Montreal, " 263 pp.
1863. " General Report, from 1843 to 1863, Montreal, 8vc, xxvii and 983 pp. Atlas.
1858. *E. Billings*, *J. W. Salter* and *T. R. Jones*, Decade III, Cystideæ, Asterideæ and Entomostraca, Montreal, 8vo, 102 pp., 11 pl.
1859. *J. W. Salter*, Decade I, L. Silurian fossils, Montreal, 8vo, 47 pp., 10 pl.
" *E. Billings*, Decade IV, L. Silurian Crinoideæ, Montreal, 8vo, 72 pp., 10 pl.
1865. *Jas. Hall*, Decade II, Graptolites of Quebec Group, Montreal, 8vo, 151 pp., 23 pl.
1865. *E. Billings*, Paleozoic fossils of Canada, Montreal, 8vo, 426 pp.
1866. " Catalogue Silurian Fossils of Anticosti, Montreal, 8vo, 93 pp.
1866. *W. E. Logan*, Rep. Progress from 1863 to 1866, Ottawa, 8vo, 322 pp.

BRITISH AMERICA.

1858. *Henry Y. Hind*, Rep. of Explor. between Lake Superior, and Red River, Toronto, 8vo, 425 pp., maps.
1860.* *H. Y. Hind*, Rep. on Assiniboine Exped. in 1858–9, Toronto, folio, maps.

1863.* *H. Y. Hind*, Rep. of Explor. in Labrador, London, 8vo, 2 vols., maps.

1860. *Oscar M. Lieber*, Rep. on Geology of Labrador, (U. S. Coast Survey), Washington, 4to, 7 pp.

ARCTIC REGIONS.

1819. *John Ross*, Voyage to Baffins' Bay, &c. (Appendix, on Geology, by John McCulloch), London, 8vo.

1822. *John Franklin*, Exped. to Polar Sea, 1819–22. (Appendix on Geology by John Richardson), London, 4to.

1828.* *W. E. Parry*, 3d Voyage of Discovery in 1827. (Appendix on Geology by Robt. Jameson), London.

1828. *J. Franklin*, 2d Expd. to Polar Sea in 1825–7. (Appendix on Geology, by J. Richardson; Paleontology, by R. Jameson), London, 4to.

1835. *J. Ross*, 2nd Voyage of Discovery in 1829–33. (Geology by Author,) London, 4to, 2 vols.

1836.* *G. Bach*, Arctic Land Exped. in 1833–5. (Appendix on Geology, by W. H. Fitton), London, 8vo.

1839. *F. W. Beechey*, Exped. to Pacific and Behren Strait. (Appendix on Geology, by Wm. Buckland), London, 4to.

1852.* *P. C. Sutherland*, Journal of Voyage in Baffin's Bay, in 1850–51. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols., plates.

1855. *E. Belcher*, Exped. to Arctic in 1852–4. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols.

ADDITIONS AND CORRECTIONS TO PART I.

MAINE.

For the last three Reports on this State read as follows:—

1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, Augusta, 12mo, 78 pp.

1862. *E. Holmes* and *Chas. H. Hitchcock*, 1st Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 387 pp.

1863. *E. Holmes* and *C. H. Hitchcock*, 2nd Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

NORTH CAROLINA.

1867. *W. C. Kerr*, Rep. Progress of Survey, Raleigh, 8vo, 56 pp.

FLORIDA.

1851. *Louis Agassiz*, Rep. on Florida Coral-reefs, (U. S. Coast Survey), Washington, 8vo, 15 pp.

ILLINOIS.

1867. *A. H. Worthen*, Rep. Paleontology, vol. II, Springfield, large 8vo, 474 pp. 50 plates. (Vertebrates by J. S. Newberry and A. H. Worthen; Invertebrates by F. B. Meek and A. H. Worthen; and Plants by Leo Lesquereux.)

5. *Note to Article on Kaolinite, etc.*, p. 361; by the authors.—When our article was just going to press, we received a letter from Prof. A. Knop, dated Carlsruhe, March 13th, directing our attention to his extremely interesting paper, *Beiträge zur Kenntniss der Steinkohlen-Formation und des Rothliegenden im erzgebirgischen Bassin*, *Neues Jahrbuch für Min.*, 1859, in which we find, p. 544, details of his investigation on the crystallography of the Schneckenstein "Kaolin." Prof. Knop has anticipated our observations on this substance in good part, as appears from the following quotation. "The crystals of the Kaolin from Schneckenstein have dimensions admitting of measurement under the microscope. They have an average length of about 0·021 mm., and a breadth of about 0·015 mm., and show, in part, the form of very sharply defined rhombic tables; in part, these are variously truncated on the angles connected by the macrodiagonal. Here and there the crystal-plates are aggregated to rhombic prisms and exhibit, on the assumption of rhombic crystallization, the combinations $\infty P . 0P$ and $\infty P . 0P . \infty \breve{P} \infty$. Repeated measurements gave constantly 118° for the obtuse angles of the planes."

The specimen from Schneckenstein kindly sent us by Prof. Knop, who first brought it to Wöhler's notice, perfectly resembles that received from Prof. Clark, as well as others adhering to topaz specimens from Schneckenstein in Prof. Brush's collection. These crystals are, however, too small for measurement by the means at our command. If the angle given by Prof. Knop be correct, we presume that more exact goniometry would prove the same true of the kaolinite from Summit Hill, the crystals of which, being six times larger in linear dimensions, we have measured without difficulty, though not with great precision. In our figures of the last named substance, drawn by the camera lucida, the angles vary one and in some cases two degrees; but they never fall below 118°, the opposite angles vary as much as those contiguous to each other, and they all point to 120° as the mean.

Prof. Knop has also favored us with a portion of the kaolin from Zeisigwald before referred to. The plates average ·0002 inch in breadth, and are finer than those of some plastic clays we have examined. Under an $\frac{1}{8}$ in. objective we have detected short bundles of plates, but in a cursory examination did not discover plates with a definite angular outline.

As regards pholerite, we learn from Prof. Knop's paper, that the mineral from Niederrabenstein, described by him, is not a homogeneous substance, but in the sample analyzed contained 7·91 per cent of quartz and other impurities, insoluble in concentrated sulphuric acid. The analysis quoted in our table is that of the portion soluble in sulphuric acid.

The substance itself, known as *Thonstein* or *Felsittuff*, was of close texture, easily cut by the knife and appeared when "magnified 330 diameters as a mass of fine crystalline colorless scales, which were of themselves only in part well defined or aggregated in parallel position to small thick packets."

This description agrees with what we have given of various clays, and leads to one of two conclusions, viz., either the substance is impure kaolinite, or, if pholerite, the latter has an appearance and prismatic crystallization closely similar to kaolinite.

In his analysis, Prof. Knop decomposed the substance by hot concentrated sulphuric acid, evaporated off the excess of this acid, warmed with chlorhydric acid, and dissolved in distilled water. From the undissolved residue silica was extracted by solution of caustic soda. There is one point in this method that is open to objection and might introduce a serious error in the results. In evaporating off the excess of sulphuric acid which requires a high temperature, the heat may easily rise at the close of the operation to a degree at which silica decomposes sulphate of alumina, and on subsequent treatment with chlorhydric acid, soluble silica would pass into the liquid and be included in the alumina precipitate, unless special precautions were taken. For this reason we do not regard the single analysis as conclusive of the existence of pholerite.

It is further to be observed that the pure kaolinite of Zeisigwald occurs in the same neighborhood and in cavities in a similar "thonstein."

The Naxos pholerite analyzed by Prof. J. L. Smith is described as associated with emerylite. But for the great care which Prof. Smith is known to employ in the selection of pure material, we might suppose he analyzed a mixture of kaolinite and emerylite. In fact, if we assume the 1·21 per cent of lime in his analysis to belong to emerylite, and calculate the corresponding quantities of silica, alumina and water, according to the theoretical composition of this substance as given in his paper, we obtain, after deducting these quantities from the per-centages in "pholerite," proportions of silica, alumina and water that represent kaolinite quite closely.

	Supposed pholerite.	Emerylite, calc. from lime.		Residue.	Residue calc. on 100. (kaolinite?)
$\dot{S}i$,	44·41	2·93	=	41·48	45·57
$\dot{A}l$,	41·20	4·42	=	36·78	40·40
$\dot{C}a$,	1·21	1·21			
$\dot{H}$,	13·14	0·38	=	12·76	14·01
	99·96	8·94	=	91·02	99·98

We do not regard such calculations as conclusive, but their indications are worthy of being followed up. S. W. J. and J. M. B.

6. *On a new specimen of Telerpeton Elginense;* by Prof. T. H. Huxley, LL.D., F.R.S., V.P.G.S.—The specimen which was described in this paper had been broken into five pieces, exhibiting hollow casts of most of the bones of *Telerpeton Elginense.* It is the property of Mr. James Grant of Lossiemouth, and came from the reptiliferous beds of that locality, along with some highly interesting fragments of *Stagonolepis* and *Hyperodapedon.* The casts described by the author consisted of impressions of the bones of the skull, together with the lower jaw, and the teeth; of most of the vertebræ and ribs; of the greater portions of the pelvic and scapular arches; and of representatives of most of the bones of the fore and hind limbs; and it was stated that the characters of all these portions of the skeleton indicated decidedly Lacertilian affinities.

In describing these remains Professor Huxley discussed especially the biconcave character of the vertebræ; the mode of implantation of the teeth, which he believed to be acrodont, and not thecodont; and the anomalous structure of the fifth digit of the hind foot, which presents only two phalanges (a proximal and a terminal), a structure which differs from that of all known Lacertilian reptiles, whether recent or fossil. His

researches had led him to conclude that the animal is one of the Reptilia, and is devoid of the slightest indication of affinity with the Amphibia. In all its characters it is decidedly Saurian, and accords with the sub-order *Kionocrania* of the true Lacertilia; but the author had not been able to make sure that it possesses a columella. He also remarked that the possession by *Telerpeton Elginense* of vertebræ with concave articular faces does not interfere with this view, as although most recent Lacertilia have concavo-convex vertebræ, biconcave vertebræ much more deeply excavated than those of *T. Elginense* are met with among the existing geckos.

Professor Huxley in conclusion drew attention to the interesting fact that *Telerpeton* presents not a single character approximating it toward the type of the Permian *Protorosauria*, or the Triassic *Rhynchosaurus*, and other probably Triassic African and Asiatic allies of that genus, or to the Mesozoic Dinosauria; and that whether the age of the deposit in which it occurs be Triassic or Devonian, *Telerpeton* is a striking example of a *persistent type* of animal organization.—*Geol. Mag.*, iv, 78.

7. *Note on Taltalite;* by F. Pisani. (From a letter to J. D. Dana, dated Paris, Dec. 6, 1866.)—*Taltalite* of Domeyko,* recently described by Mr. David Forbes,† comes from a copper mine of Señor Moreno near Taltal, in the desert of Atacama, where it is associated with atacamite and copper glance. It occurs in large masses, fibrous, silky in luster, brownish-black in color, and has a dark gray powder. Domeyko obtained

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{C}a$	$\dot{C}u$	Cl	$\dot{H}$	
20·8	16·2	11·3	0·8	2·4	44·5	0·7	2·25	= 98·95

affording the oxygen ratio for the bases and silica 21·83 : 11·08.

On a close examination of the mineral I have found that it is only a mixture of fibrous tourmaline and oxyd of copper. Treated with chlorhydric acid, it leaves a residue which contains boracic acid, and has the reactions of tourmaline; and the solution includes all the copper with but very little iron, no cobalt or manganese, and traces of lime. Besides, if from Domeyko's results we take all the oxyd of copper which the acid takes up, we obtain for the remainder—

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{C}u$	$\dot{H}$	
38·7	30·1	21·2	1·49	4·41	4·1	= 100.

These numbers agree with those of a very ferriferous tourmaline, excepting the absence of boracic acid which Domeyko did not detect. I have in my collection a specimen of blackish-brown fibrous tourmaline from Chili, which is free from oxyd of copper. What has been called *taltalite* is similar, excepting the accidental mixture of oxyd of copper.

8. *On the punctate shell structure of Syringothyris;* by F. B. Meek. (From a letter to one of the editors, dated Washington, April 18th, 1867.)—I write a brief note to inform you that I have recently examined Prof. Winchell's types of his genus *Syringothyris*, which he was so kind as to loan me, and that I find them all, with the exception of two silicified specimens (showing no structure), *distinctly punctate.* It is probable that Prof. Winchell had happened to examine chippings from specimens not in a condition to show the punctures. I have likewise ascertained, since the publication of my former paper on this subject, that *Spirifer propinquus* Hall, and *S. Hannibalensis* Swallow, both nearly

* Domeyko's Mineralogy, 2d edit., p. 139, 1860. † Phil. Mag., [4], xxv, 111.

like *S. cuspidatus*, have a clearly punctate structure, and hence probably belong to the group *Syringothyris*.

I have also just read a letter from Mr. Davidson, written to Mr. Worthen, in which he quotes, from a letter to him from Dr. Carpenter, a paragraph giving the results of his examinations of specimens of *Syringothyris*, and of the same Irish shell examined by me (and at one time supposed to be *Spirifer cuspidatus*). These chippings were sent over by Mr. Worthen at Mr. Davidson's request some little time back. Dr. Carpenter says he finds the *Syringothyris* (that from Floyd Co., Indiana, I suppose) *distinctly punctate*, the punctures being as I stated, small and scattering. The chippings from the Irish specimen, sent over to Mr. Worthen with the name *S. cuspidatus* attached, Dr. Carpenter also found to be punctured, though the punctures are not so clearly seen as in the other. Chippings of *S. subcuspidatus* Hall, sent by Mr. Worthen, he says are not in a condition to show the structure.

At the time of writing, Dr. Carpenter had evidently not received a package of chippings I had sent him, containing specimens of *S. subcuspidatus* showing the punctures clearly. He says these examinations of the structure of *Syringothyris* confirm its generic or subgeneric differentiation established upon other characters, and that the Irish specimen he believes belongs to this group. He is still confident, however, that the *true S. cuspidatus* is not a punctate shell, which you will remember I had not supposed to be the case. I never doubted or questioned the accuracy of Dr. Carpenter's conclusions on that point; and there is no microscopist living in whose results I have more confidence than in his.*

9. *Geological Researches in China, Mongolia, and Japan during the years* 1862 *to* 1863; by RAPHAEL PUMPELLY. 144 pp., 4to, with 9 plates. Washington City. Published by the Smithsonian Institution, being No. 202 of the Smithsonian Contributions to Knowledge.—In vol. xli of this Journal, Mr. Pumpelly gave a very brief notice of the principal results to which he had arrived after his explorations in China and Japan. The volume issued contains a full account of his very interesting observations. It treats of the General Outlines of Eastern Asia; its general geology, with an account of his special explorations in China and Japan; the structure of the Southern edge of the Great Table-Land, and of Northern Shansi and Chihli; the Sinian system of elevation; the Yellow Stone and its delta and changes of course; and the Mineral Productions of China; and gives, in an Appendix, Dr. Newberry's descriptions of the Fossil Plants of the Coal rocks, with plates; J. A. Macdonald's analyses of Chinese and Japanese Coals; and the results of Mr. A. M. Edwards's microscopic examination of some Japanese infusorial earths and other deposits of China and Mongolia.

The Sinian system of elevation is the "extensive N.E. and S.W. system of upheaval, which is traceable through nearly all Eastern Asia, and to which this portion of the continent owes its most salient features." It is stated

* In a paper on certain types of the Spiriferidæ published in the Proceedings of the American Philosophical Society for 1866, and presented to that Society in May of 1866, Mr. J. Hall presents facts confirming my observations, communicated in a paper read before the Philad. Acad. Nat. Sci., in Dec. 1865, and published Feb. 1866, in which the presence of a punctate structure in shells of this type, and its coincidence with the internal tube of *Syringothyris*, were first announced. He, however, makes no allusion to my investigations, of which he certainly was not ignorant.

to be extensively apparent in the courses of the mountains, the strike of the strata, and the hydrography. It characterizes the trend of the metamorphic rocks over the plateau from Mongolia from the Great Wall to Siberia; and a map shows that it belongs to all Eastern Siberia, the Yablonvi, Altan-Kingan, and Stanovoi Mts., with their intermediate ridges, conforming to it. The period of the uplift is placed before that of the Coal-measures (Mesozoic). Mr. Pumpelly remarks that striking analogies are observed to exist between the Sinians and our own Appalachians, as to structure, strike, and dip; and that as the elevation of the Appalachians determined the outline of Eastern America, so the Sinian revolution fixed the eastern boundary of the great Asiatic continent.

10. *Nuove Osservazioni Geologiche sulle Rocce Anthracitifere delle Alpi;* del Commendatori ANGELO SISMONDA, Prof. di Min. nella Regia Universita di Torino. 26 pp., 4to, with colored maps. Turin, 1866.—Prof. Sismonda, in this paper, treats of the age of certain stratified rocks occurring among the metamorphic of the Alps of Savoy, which contain anthracite and plants of the Carboniferous age along with remains of animals of Liassic and Oolitic age. Sismonda concludes that there are three consecutive groups of these rocks; a lower, which is Liassic in its mollusks; a middle, with Liassic and Oolitic fossils; and above this a quartzose conglomerate and sandstone with anthracite, and supposed to be of the age of the Oxfordian clay. The Carboniferous plants are found both in the lower and upper.

11. *Ueber ein Æquivalent der takonischen Schiefer Nordamerika's in Deutschland und dessen geologische Stellung;* von Dr. H. B. GEINITZ und Dr. K. Th. LIEBE, Professoren in Dresden und Gera. 52 pp., 4to, with 8 lithographic plates and several wood-cuts.—The plates of this memoir contain figures of different Annelids and Fucoids from the slates near Wurzbach, which bear much resemblance to those that occur in rocks *called* Taconic in North America.

12. *Note on the genus Palæaster and other Fossil Starfishes,* with descriptions of some new species; by JAMES HALL. 24 pp., 8vo. From the Twentieth Report on the State Cabinet of Natural History. Published (to page 21) in advance of Report, Nov. and Dec., 1866.

13. *Descriptions of some new species of Crinoidea and other fossils* from the Lower Silurian strata of the age of the Hudson River Group and Trenton limestone; by JAMES HALL. Printed, in advance, from the Report on the State Cabinet for 1866, and issued Nov. 1866.

III. BOTANY AND ZOOLOGY.

1. *Catalogus Plantarum Cubensium, exhibens Collectionem Wrightianum aliasque minores ex Insula Cuba missas quas recensuit* A. GRISEBACH, Professor Göttingensis. pp. 301, 8vo. Leipsic, 1866. (Engelmann.)—Although printed a year ago (the preface bears the date of April, 1866), the derangements incident to the short war which last summer wrought such changes in Germany, in some way delayed until recently the publication of this little volume. It is now to be had of B. Westermann & Co., 440 Broadway, New York; and it is indispensable to those botanists who possess any part of Mr. Wright's rich Cuban collections of botanical specimens, which are cited by the numbers under which they were distributed. A goodly number of clerical or typographical errors (beyond those

indicated on pp. 287, 288), as also errors in the distribution, call for correction. It is to be hoped that Mr Wright will some day print a revised list in the order of their numbers. Meanwhile the writer of this notice will furnish to any possessors of these specimens who apply for them such corrections as he has been able to make in his own copy. As might have been expected the flora of Cuba proves to be very rich. This Catalogue contains—

Dicotyledons,	2350,	of which	781	are peculiar to the	Island.	
Monocotyledons,	634	"	148	"	"	"
Vascular Cryptogamia,	279	"	10	"	"	"
Total,	3263	"	939	"	"	"

And Mr. Wright's more recent explorations, which are still in progress, will largely increase the number. If Hayti could now be equally explored, the flora of the West Indies could be written with some approach to perfection.

Characters of the new species only (and these are very many) are given in this volume. The diagnoses of the new *Euphorbiaceæ* are, however, unfortunately omitted, having been published by anticipation, in the Nachrichten of the Göttingen Royal Society of Science. Now that we have, thanks to Professor Grisebach's studies, so good a foundation for Cuban botany, we may hope that our indefatigable explorer may crown his prolonged and laborious researches by a general revision of the flora of the island. A. G.

2. *Flora Australiensis*, Vol. III. *Myrtaceæ* to *Compositæ*, 1866.—This great work makes rapid progress in Mr. Bentham's able hands. The present volume comprises the largest and most difficult Australian order, the *Myrtaceæ*, and the usually paramount order *Compositæ*, these two filling a little more than three quarters of the 680 pages of this volume, which also contains the *Umbelliferæ* and the *Rubiaceæ*, usually of no small size. A. G.

3. *The Geographical Distribution of Mammals;* by Andrew Murray. 420 pp., 4to, with 105 chromo-lithographic maps. London, 1866. (Day & Son.)—This beautiful volume treats those subjects *in extenso* which are merely glanced at in the physical atlases of Johnston and others, including the distribution of fossil species according to their geological position, and discussions of the views of Agassiz and Darwin, without adopting either in full. The work extends to forty-three chapters, with an extended appendix and numerous cuts illustrating animal peculiarities.

Geological questions are discussed and maps given of the 100-fathom line of soundings; the effect of a depression of the land 600 feet; Tertiary and Quaternary formations; localities of glacial action; rising and falling of land of the present period; and the sargasso seas. The maps of mammal distribution then commence with the human race, chapter vii, p. 56, but two branches of which are acknowledged, the black and white, the latter including all except the negroes and Australians, with their affinities.

The completeness of the work may be judged from the extent to which groups and genera are located. Maps 7–10 are devoted to the distribution of monkeys; 13, to the lion; 14, to the tiger; 17, fossil hyenas; 18, existing hyenas; 26, bears; 29, hippopotamus (living and fossil);

30, swine; 34, goats; 35, sheep; 46, rhinoceros (living and extinct); 47, mastodons and elephants in Lower Miocene; 48, in Upper Miocene; 49, in Pliocene; and 50, existing elephants.

The appendix (pp. 312–412) is devoted to the classification of mammals proposed by different authors; a synonymic list of the species and their localities, distinguishing the extinct species; and mammals of special districts, as Spitzbergen, Nova Zembla, Greenland, Iceland, Sweden, France, Sahara, Japan, &c. North America is given under eight districts exclusive of Mexico.

A work of so much value, published in a style which precludes a return for the outlay, should have a place in the libraries of all who wish to encourage research in the cognate fields upon which the learned author is understood to be engaged. S. S. H.

4. *Observations on the Genus Unio, together with Descriptions of new species in the Family Unionidæ, and Descriptions of new species of the Melanidæ, Limneidæ, Paludinæ, and Helicidæ;* by ISAAC LEA, LL.D. 146 pp., 4to, with 24 plates. Philadelphia. (Read before the Academy of Natural Sciences of Philadelphia, and published in their Journal.)—This volume is the eleventh in Dr. Lea's series on the Unionidæ. Like the preceding, it contains very large additions to the number of species, and is beautifully and generously illustrated. The introduction states that the number of new species of Unionidæ here described is 180, and of the other groups mentioned above, 118. The former are mainly from the Southern States, a few from Western Asia, and Lake Nyassa in Central Africa. The univalves are mostly of the U. States, but some are from Central America and Asia.

5. *An Inquiry into the Zoological relations of the first discovered traces of Fossil Neuropterous Insects in North America: with Remarks on the difference of structure in the wings of living Neuroptera;* by S. H. SCUDDER. 20 pp., 4to. From Vol. I of the Mem. of the Bost. Soc. Nat. Hist., Jan. 1865.—The paper discusses the characters of the fossil insects from the coal rocks of Illinois, described in vol. xxxvii of this Journal, with results of great interest to science.

6. *On the Osteology and Myology of Colymbus torquatus;* by ELLIOTT COUES, A.M., M.D., Brevet Capt. and Assist. Surgeon, U.S. Army. 42 pp., 4to. From vol. I of the Mem. of the Bost. Soc. Nat. Hist., Nov. 1866.

7. *Notes on the Zygænidæ of Cuba;* by A. R. GROTE. 18 and 38 pp., 8vo, with plates. From the Proceedings of the Entomological Society of Philadelphia, Part I, July, 1866, and Part II, Jan., 1867.

IV. ASTRONOMY.

1. *On the Obscuration of the Lunar Crater "Linné;"* by W. B. BIRT, Esq.—The interesting phenomenon of a change in the appearance of the crater "Linné" was communicated to me by Herr Schmidt, the Director of the Observatory at Athens, an extract from whose letter is as follows:

"For some time past I find that a lunar crater situated in the plain of the *Mare Serenitatis* has been invisible. It is the crater which Mädler named Linné, and is in the fourth section of Lohrmann, under the sign A. I have known this crater since 1841, and even at the full it has not been difficult to see. In October and November, 1866, at its epoch of

maximum visibility, i. e., about the time of the rising of the sun on its horizon, this deep crater, whose diameter is 5·6 English miles, had completely disappeared, and in its place there was only a little whitish luminous cloud. Be so kind as to make some observations on this locality."

The earliest information respecting the crater I received from Mr. Buckingham, who favored me with a copy of a photograph taken by him on November 18, 1866. On this photograph the place of "Linné" is visible, but faint. I have during the last lunation received records of observations from the following gentlemen: Doctors Mann and Tietjen, and Messrs. Talmage, Webb, Slack, Grover, and Jones. On the 13th, when the terminator passed over the east boundary of the *Mare Serenitatis*, the place of "Linné" was seen by Messrs. Webb and Talmage; Mr. Webb's aperture 9¼-inch silvered glass reflector, and Mr. Talmage's 10-inch refractor of Mr. Barclay at Leyton. Mr. Webb described the appearance as an ill-defined whitishness on the site of "Linné." Mr. Talmage recorded "a dark circular cloud." The exact position of these appearances was carefully ascertained afterward and found to agree with the place of "Linné." Doctor Mann and myself at Leyton were prevented by a thin veil of cirrus seeing the "cloud" recorded by Mr. Talmage. With smaller apertures both Mr. Grover and myself were unable to detect the slightest trace of "Linné," while the small crater "Linné B" of Beer and Mädler, and also Bessel, were very distinct *with the shadows within them.* On the following evening, December 14th, observations were made by Messrs. Webb, Slack, Grover, and Birt. A white spot was seen in the position of "Linné." Mr. Webb described it as the most conspicuous object on the east half of the *Mare Serenitatis.* Mr. Slack saw a whitish spot not remarkably bright, but could see no trace of a crater. Mr. Grover recorded "a tolerably defined roundish whitish speck," but he could not see the interior or margin of the crater, and "in this respect the spot showed very different from Bessel and other craters which were well seen." My own observations perfectly agree with the above. I estimated the light at 3°. On the 15th the spot was brighter, and I obtained the measures recorded below. On the 16th Messrs. Jones and Grover described the appearance as a white spot not over bright.

On the 20th Professor Foërster and Dr. Tietjen observed "Linné" with the Berlin refractor. The following is the translation of the letter which I received from Dr. Tietjen, dated Berlin, 21 December, 1866:

"On viewing the moon last night about 13^h M.T. Berlin with our refractor, in order to convince ourselves of the disappearance of the crater 'Linné,' Professor Foërster and myself perceived that crater very distinctly. If, therefore, an obscuration has taken place, on which certainly no doubt can exist, as it is affirmed by so competent an authority as Herr Schmidt of Athens, it has evidently now ceased."

Although Dr. Tietjen considers that the obscuration *has ceased*, it does not appear that either he or Professor Foërster *has seen into* the crater.

The whole of the observations are so accordant among themselves, and the measures appended so clearly indicate the white spot to be larger than the crater "Linné," as to leave no doubt that a change of some kind has taken place; and this conclusion appears to be supported by previous records which are here appended:

Date.	Authority.	Brightness.
1653,	Riccioli.	○
1788, Nov. 5,	Schröter,	0·5
1823, May 28,	Lohrmann,	7·0+
1831, Dec. 12, 13,	Beer and Mädler,	6·0
1858, Feb. 22,	De la Rue,	5·0
1865, Oct. 4,	"	5·0
	Rutherfurd,	6·0
1866, Nov. 18,	Buckingham,	2·0

The last four determinations of brightness are from photographs. There is some uncertainty in determining this element on the prints. Schröter, in plate IX of his Selenophotographische Fragmente, gives a large dark spot in the place of "Linné;" and the Rev. T. W. Webb informs me that "Linné" is not to be found on Russell's globe or maps, 1797, from which it may be inferred that the crater has previously been obscured.

The following measures were made during the last lunation:

Date. 1866.	Dionysius.	Linné.	Mag.	Miles.	Brightness. ○
Dec. 15	14·70	11·61	0·79	10·9	4
18	14·13	7·07	0·50	6·9	5·5
19	13·95	7·32	0·52	7·2	5
21	13·32	6·75	0·51	7·0	4

The numbers in column 4 headed "Mag." are obtained by dividing the measures of "Linné" by the measures of the standard spot "Dionysius." The normal magnitude of "Linné" is 0·40 ("Dionysius" being unity) as determined by two independent methods. The numbers in column 5 headed "Miles" are not absolute, but only relative as compared with "Dionysius," by means of the numbers in column 4. "Dionysius," according to Lohrmann, is 13·8 English miles, and "Linné," according to Schmidt, 5·6 English miles in diameter. During the lunation no trace of the *crater* was seen.—*Monthly Notices Roy. Astr. Soc.*, Jan. 11, 1867.

2. *Shooting Stars seen in Colorado.*—The Denver News gives the following numbers of meteors seen at that place (N. lat. 39° 40′, W. long. 105°) in intervals of five minutes at different times on the morning of Nov. 14th, 1866. The number of observers is not stated.

At 12h 0m,	5 meteors.	At 1h 25m,	5 meteors.	At 3h 30m,	5 meteors.
12 20	3 "	2 0	5 "	4 0	12 "
12 30	7 "	2 30	14 "	5 15	10 "
12 45	9 "	2 45	11 "		
1 0	4 "	3 0	21 "	Total in 65m,	101 "

3. *Astronomical and Meteorological Observations made at the United States Naval Observatory during the year* 1864. Captain J. M. Gilliss, U.S.N., Superintendent. 524 pp., 4to. Published by authority of the Hon. Secretary of the Navy. Washington, 1866.—This important volume contains the following tables: (1.) Observations with the Meridian Transit Instrument; (2.) ib. with the Mural Circle; (3.) ib. with the Equatorial; (4.) Mean right ascensions, for 1860·0 of stars observed with the Transit; (5.) Mean declination, obs. with the Mural Circle; (6.) Right ascensions, declinations, and semi-diameters of the Sun, Moon, and Planets; (7.) Constants for the reduction of fixed stars; (8.) Catalogue of stars observed in 1864; (9.) Meteorological observations.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Additional Gifts to Science from George Peabody, Esq.*—Since the notice of Mr. Peabody's recent donations to science, which appeared in the January number of this Journal, this gentleman has given about $2,000,000 for the promotion of education in the South and Southwest. This munificent gift was accompanied by the following letter to the Trustees of the fund:—

To Hon. Robert C. Winthrop, of Massachusetts; Hon. Hamilton Fish, of New York; Right Rev. Charles P. McIlvaine, of Ohio; General U. S. Grant, of the United States Army; Admiral David G. Farragut, of the United States Navy; Hon. William C. Rives, of Virginia; Hon. John H. Clifford, of Massachusetts; Hon. William Aiken, of South Carolina; William M. Evarts, Esq., of New York; Hon. William A. Graham, of North Carolina; Charles Macalester, of Pennsylvania; George W. Riggs, Esq., of Washington; Samuel Wetmore, Esq., of New York; Edward A. Bradford, Esq., of Louisiana; George N. Eaton, Esq., of Maryland; and George Peabody Russell, Esq., of Massachusetts.

GENTLEMEN: I beg to address you on a subject which occupied my mind long before I left England, and in regard to which, one at least of you (the Hon. Mr. Winthrop, the distinguished and valued friend to whom I am so much indebted for cordial sympathy, careful consideration, and wise counsel in this matter) will remember that I consulted him immediately upon my arrival in May last.

I refer to the educational needs of those portions of our beloved and common country which have suffered from the destructive ravages, and the not less disastrous consequences of civil war.

With my advancing years my attachment to my native land has but become more devoted. My hope and faith in its successful and glorious future have grown brighter and stronger, and now, looking forward beyond my stay on earth, as may be permitted to one who has passed the limit of three score and ten years, I see our country united and prosperous, emerging from the clouds which still surround her, taking a higher rank among the nations, and becoming richer and more powerful than ever before.

But to make her prosperity more than superficial, her moral and intellectual development should keep pace with her material growth; and in those portions of our nation to which I have referred, the urgent and pressing physical needs of an almost impoverished people must for some years preclude them from making, by unaided effort, such advances in education, and such progress in the diffusion of knowledge among all classes, as every lover of his country must earnestly desire.

I feel most deeply, therefore, that it is the duty and privilege of the more favored and wealthy portions of our nation to assist those who are less fortunate; and, with the wish to discharge so far as I may be able my own responsibility in this matter, as well as to gratify my desire to aid those to whom I am bound by so many ties of attachment and regard, I give to you, gentlemen, most of whom have been my personal and especial friends, the sum of one million of dollars, to be by you and your

successors held in trust, and the income thereof used and applied in your discretion for the promotion and encouragement of the intellectual, moral, or industrial education among the young of the more destitute portions of the Southern and Southwestern States of our Union; my purpose being that the benefits intended shall be distributed among the entire population, without other distinction than their needs and the opportunities of usefulness to them.

Besides the income thus derived, I give to you permission to use from the principal sum, within the next two years, an amount not exceeding forty per cent.

In addition to this gift I place in your hands bonds of the State of Mississippi, issued to the Planter's Bank, and commonly known as Planter's Bank Bonds, amounting, with interest, to about eleven hundred thousand dollars, the amount realized by you from which is to be added to and used for the purposes of this trust. * * * * * * * *

The details and organization of the trust I leave with you, only requesting that Mr. Winthrop may be Chairman, and Governor Fish and Bishop McIlvaine Vice-Chairmen of your body; and I give to you power to make all necessary by-laws and regulations, to obtain an act of incorporation, if any shall be found expedient, to provide for the expenses of the trustees and of any agents appointed by them, and generally, to do all such acts as may be necessary for carrying out the provisions of this trust.

All vacancies occurring in your number by death, resignation, or otherwise, shall be filled by your election, as soon as conveniently may be, and having in view an equality of representation so far as regards the Northern and Southern States.

I furthermore give to you the power, in case two-thirds of the trustees shall at any time, after the lapse of 30 years, deem it expedient, to close this trust, and of the funds which at that time shall be in the hands of yourselves or your successors, to distribute not less than two-thirds among such educational or literary institutions, or for such educational purposes as they may determine, in the States for whose benefit the income is now appointed to be used. The remainder may be distributed by the trustees for educational or literary purposes wherever they may deem it expedient.

In making this gift I am aware that the fund derived from it can but aid the States which I wish to benefit in their own exertions to diffuse the blessings of education and morality. But if this endowment shall encourage those now anxious for the light of knowledge, and stimulate to new efforts the many good and noble men who cherish the high purpose of placing our great country foremost, not only in power, but in the intelligence and virtue of her citizens, it will have accomplished all that I can hope.

With reverent recognition of the need of the blessing of Almighty God upon this gift, and with the fervent prayer that, under his guidance, your counsels may be directed for the highest good of present and future generations in our beloved country, I am, gentlemen, with great respect, your humble servant,

GEORGE PEABODY.

Washington, Feb. 7, 1867.

More recently Mr. Peabody has given $140,000 to the Essex Institute in Salem, Mass., for the promotion of the Natural and Physical Sciences in his native county. Of this sum $100,000 is to be kept as a permanent fund, and the income to be devoted to various branches of science. The remainder of the gift will be chiefly expended on the Museum of Natural History. Mr. Peabody's letter to his Trustees announcing this donation was as follows:—

Salem, Feb. 26, 1867.

To Francis Peabody, Esq., Prof. Asa Gray, Wm. C. Endicott, Esq., Geo. Peabody Russell, Esq., Prof. O. C. Marsh, Henry Wheatland, A. C. Goodell, Jr., James R. Nichols, and Henry C. Perkins, Esqs.

Gentlemen: As you will perceive by the inclosed instrument of Trust, I wish to place in the hands of yourselves and your successors, the sum of one hundred and forty thousand dollars, for the promotion of Science and Useful Knowledge in the County of Essex.

Of this, my native county, I have always been justly proud, in common with all her sons, remembering her ancient reputation, her many illustrious statesmen, jurists and men of science; her distinguished record from the earliest days of our country's history, and the distinction so long retained by her, as eminent in the education and morality of her citizens.

I am desirous of assisting to perpetuate her good name through future generations, and of aiding through her means in the diffusion of science and knowledge; and, after consultation with some of her most eminent and worthy citizens, and encouraged by the success which has already attended the efforts and researches of the distinguished Scientific Association of which your Chairman is President, and with which most of you are connected, I am led to hope that this gift may be instrumental in attaining the desired end.

I therefore transmit to you the inclosed instrument, and a check for the amount therein named ($140,000), with the hope that this Trust, as administered by you and your successors, may tend to advancement in intelligence and virtue, not only in our good old county of Essex, but in our Commonwealth, and in our common country.

I am, with great respect, your humble servant,

(Signed) George Peabody.

Mr. Peabody has, moreover, recently given $20,000 to the Massachusetts Historical Society, and $15,000 each to Newburyport, Mass., and Georgetown, D. C., to found free public libraries in those cities.

These various gifts increase the amount of Mr. Peabody's recent benefactions to science and education in this country to nearly four millions dollars,—a truly noble and unparalleled record of private munificence.

2. *Ascent of Mount Hood, Oregon;* by the Rev. H. K. Hines.*—In September of 1864, in company with three gentlemen of Vancouver, I first attempted to reach the summit of Mount Hood. On reaching an altitude about 800 feet below the summit, a dense cloud came sweeping against the north side of the mountain, and, drifting rapidly over it, instantly enveloped us in its folds. The air changed suddenly to a fierce cold. The driving snow filled the air so entirely that a cliff of rocks 300 feet high, standing not more than fifty feet from us, was invisible.

* From the Proceedings of the Royal Geographical Society, March 23, 1867.

To go up or to go down, was, for the time, alike impossible. One of my companions was chilled nearly to insensibility, but we struggled against the tempest for hours, unwilling to be defeated in our purpose to reach the summit.

On the morning of the 24th of July, 1866, in company with three gentlemen of the city of Portland, Oregon, I set out full of determination to stand upon the summit, if energy and endurance could accomplish the feat. Our rendezvous was at the house of a Canadian, who, fourteen years before, had erected a cabin at the place where the emigrant road leaves the mountains and enters the valley of the Willamette. From this place the track enters the mountains along the gorge through which flows a dashing river about 300 feet in width, wh ch r ses beneath the glaciers of Mount Hood. Up this stream we travelled for 30 miles, when, leaving the gorge, the way makes a *détour* to the south to gain the summit ridge. Here is the celebrated "Laurel Hill." For three or four miles the ascent is continuous, and in many places very steep.

Reaching the top of Laurel Hill we were on the general summit of the range: a comparative level of perhaps 10 miles in width, whose general character is that of a swamp or marsh. On this plateau is a dense and grand growth of fir, cedar (*Thuja gigantea*, Nutt.), pine and kindred evergreens, with an almost impenetrable undergrowth of laurel (*Rhododendron maximum*, Hook). Straggling rays of sunlight only here and there find way through the dense foliage to the damp ground. Passing over this level we crossed several bold clear streams, coursing down from the direction of Mount Hood, and then, turning to the left, we took an old Indian trail leading in the direction of the mountain. After a ride of an hour and a half up a continuous and steep ascent, we came to an opening of scattered trees which sweeps around the south side of the mountain. It was about five o'clock when we emerged from the forest, and stood confronting the wonderful body of rock and snow which springs up from the elevation.

We selected a place for our camp on a beautiful grassy ridge between one of the main affluents of the Deschutes river and one of the Clackamas, and which nearly constitutes the dividing ridge of the mountain. Having erected here a hut of boughs and gathered fuel for a large fire during the night, we spread our blankets on the ground and slept well until the morning. We picketed our horses in this place. At seven o'clock of Thursday we were ready for the ascent. For the first mile and a half the ascent was very gradual and easy, over a bed of volcanic rock, decayed and intermixed with ashes. Huge rocks stood here and there, and occasionally a stunted juniper found a precarious foothold; some beautiful variegated mosses were also seen clinging to little knolls of sand. We soon reached the foot of a broad snow-field, which sweeps around the south side of the mountain several miles in length, and extending upward to the immediate summit. The first part of this ascent is comparatively easy, being smooth, and only in places so steep as to render the footsteps uncertain. Near the upper edge of this field of snow, the deep gorges, from which flow affluents of the streams Deschutes on the right, and Sandy river on the left, approach each other and seem to cut down into the very foundation of the mountain. The

waters were rushing from beneath the glaciers, which at their upper extremity were rent and broken into fissures and caverns of unknown depths.

The present summit of the mountain is evidently what was long since the northern rim of an immense crater, which could not have been less than three miles in diameter. The southern wall of the crater has fallen completely away, and the crater itself become filled with rock and ashes overlaid with the accumulated snows of ages, through the rents and chasms of which now escape smoke, steam and gases from the pent-up fires below. The fires are yet so near that many of the rocks which project upward are so hot that the naked hand cannot be held upon them. Just at the southwest foot of the circular wall, now constituting the summit, and at a distance of near 2000 feet from its extreme height, is now the main opening of the crater. From this a column of steam and smoke is continually issuing, at times rising and floating away on the wind, at other times rolling heavily down the mountain. Into this crater we descended, as far as it was possible to go without ropes or a ladder. The descent was stopped by a perpendicular precipice of ice 60 or 70 feet high, resting below on a bed of broken rock and ashes so hot as immediately to convert the water, which dripped continually from the icy roof 100 feet above, into steam. The air was hot and stifling.

At this point the real peril of the ascent begins. It leads out and up the inner wall of what was once the crater, and near 1000 feet of it is extremely steep. The whole distance is an ice-field, the upper limit of a great glacier which is crushing and grinding its slow journey down the mountain far to the right. About 700 feet from the summit a *crevasse*, varying from 5 to 50 feet in width, and of unknown depth, cuts clear across the glacier from wall to wall. There is no evading it. The summit cannot be reached without crossing it. Steadily and deliberately poising myself on my staff, I sprang over the chasm at the most favorable place I could select, landing safely on the declivity 2 or 3 feet above it, and then with the staff assisted the others to cross. The last movement of 15 feet had considerably changed the prospect of the ascent. True, the crevasse was passed, but we were thrown directly below a wall of ice and rocks 500 feet high, down which masses, detached by the heat of the sun, were plunging with fearful velocity. To avoid them it was necessary to skirt the crevasse on the upper side for a distance, and then turn diagonally up the remaining steep. It was only 700 feet high, but it was two hours' sinewy tug to climb it. The hot sun blazed against the wall of ice within two feet of our faces, and the perspiration streamed from our brows, but on nearing the summit the weariness seemed to vanish, and with a feeling of triumph we bounded upon the pinnacle of the highest mountain in North America.

The summit was reached at about the center of the circular wall which constitutes the extreme altitude, and it was so sharp that it was impossible to stand erect upon it. Its northern face is an escarpment several thousand feet high. I could only lie down on the southern slope, and, holding firmly to the rocks, look down the awful depth. A few rods to the west was a point 40 or 50 feet higher, to the summit of which we crawled, and then discovered that 40 or 50 rods to the east was a point

still higher, the highest of the mountain. We crawled back along the sharp escarpment, and in a few minutes stood erect on the highest pinnacle. This we found to be 17,640 feet high, the thermometer standing at 180°, about 40 feet below the summit, when the water boiled—giving 32 degrees of depression. This estimate makes Mount Hood higher than any summit of Europe or North America.

The view from the summit was magnificent. From south to north the whole line of the Cascade Range is at once under the eye, from Diamond Peak to Ranier, a distance of not less than 400 miles. Within that distance are Mounts St. Helen's, Baker, Jefferson, and the Three Sisters; making, with Mount Hood, eight snowy peaks. Eastward the Blue Mountains are in view, and lying between us and them are the broad plains watered by the Deschutes, John Day's, and Umatilla rivers. On the west the piny crests of the coast range cut clear against the sky, with the Willamette valley sleeping in quiet beauty lying at their feet. The broad silver belt of the Columbia winds through the evergreen valley toward the ocean. Within these limits is every variety of mountain and valley, lake and prairie, bold beetling precipices and graceful rounded summits blending and melting away into each other. It was with reluctance that at length we took the first step down the declivity.

The descent to the great crevasse, though much more rapidly accomplished, was quite as perilous as the ascent from it. We were now approaching the gorge, and a mis-step might precipitate us into unfathomed depths. Less than half an hour was sufficient to retrace the weary climbing of two hours, and standing for a moment on the upper edge of the chasm, I bounded over it where it was 8 feet wide. The impetus of the leap sent me sliding a long distance down the icy steep below.

In two hours and a half from the summit we were in our camp. * * *

3. *Meeting of the National Academy of Sciences in January*, 1867.—At the meeting of the National Academy held in the capitol at Washington in January last, commencing with the 23d of the month, the following papers were presented:

(1.) Report on the galvanic action from the association of zinc and iron by a Committee of the Academy.

(2.) Report on the deterioration and means of improving Greytown Harbor, Nicaragua, by a Committee of the Academy.

(3.) Report on proving and gauging spirits subject to duties, by a Committee of the Academy.

(4.) On some of the phenomena presented by the planet Venus when near to her inferior conjunction, by S. Alexander.

(5.) On the longitude between Europe and America and the velocity of galvanic signals in the Atlantic Cable, by B. A. Gould.

(6.) On the principles of the classification of fishes, by L. Agassiz.

(7.) Recent observations on the Glacial Phenomena of the Basin of the Great Lakes, by J. S. Newberry.

4. *Library and Geological specimens of Prof. H. D. Rogers.*—At a meeting of the Massachusetts Institute of Technology last December, the scientific library and the collection of geological specimens of the late Prof. Henry D. Rogers of the University of Glasgow, were presented to the Institute.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *A Manual of Inorganic Chemistry arranged to facilitate the experimental demonstration of the Facts and Principles of the Science;* by CHARLES W. ELIOT, Professor of Analytical Chemistry and Metallurgy, and FRANK H. STORER, Professor of General and Industrial Chemistry in the Massachusetts Institute of Technology. Boston. Printed for the authors. 1867.—We have received advance sheets of a good portion of this work, which will be completed in June. A careful examination of the 420 pages before us leads us to believe that the book will greatly contribute to extend the study of chemistry in this country. There are comparatively few students who can easily master chemistry under the system of teaching that now prevails. It is, on the one hand, impossible to make rapid progress in the acquisition of the facts of the science without a knowledge of principles; and on the other hand, principles cannot take a firm hold in the mind except as demonstrated by facts. The true method of teaching chemistry is in imitation of the process by which the science has been created, and this is primarily one of experiment and induction.

The beginner may naturally and easily put himself in the condition of an inquirer, but it is only by efforts that would exhaust and dishearten most young learners who have not naturally a special fondness for the science, that he can regard the subject from the standpoint of the sage. In the book under notice, the authors open with a brief introduction of four pages, in which the objects and scope of chemistry are concisely defined. Then they enter at once upon the consideration of the science itself, not by laying down a tedious series of general propositions or by toiling over notations, nomenclatures, and classifications, but by an account of common phenomena which are analyzed after the natural method. A few simple experiments open the way to the study of air and of its elements, of water and its ingredients. Following these, the compounds of these elements with each other, viz., the oxyds of nitrogen and ammonia, are discussed. By means of simple experiments the facts of definite combination by weight and volume are brought out, and following these demonstrations, on page 27, the discussion of atoms and molecules is introduced. In similar manner notation, typical and dualistic formulæ, dissociation, homologous series, and the most important considerations of chemical physics are introduced in their appropriate places.

The work is admirably adapted for the present transition state of the science. While not rejecting the established modes of expression in which the literature of chemistry is chiefly to be found, it presents, in our opinion, fully as much of the newer views as are appropriate to an elementary work. The student who has mastered this treatise is fitted thereby to study with profit and zest the writings of Wurtz, Kekule, Odling, Hofmann, and Frankland.

The adaptation to experimental teaching meets a want which has been pressingly felt, and should ensure the establishment of new working laboratories in our higher schools, as well as the practical drilling of a much larger number of students in those now in operation. The experiments, more than 200 in number, are all well described and easy of exe-

cution with a comparatively small outlay for materials. They are intended to be repeated by the students themselves under proper direction, and this mode of instruction which engages and disciplines the perceptive faculties and unfolds the methods of investigation is one which is more and more coming to be regarded as essential to a successful system of education.

The book is not only excellently adapted for the instruction of beginners, but, as far as its size admits, reflects very satisfactorily the present state of the science. It is entirely free from the puerilities, the blunders, and the contradictions which are so prominent in the majority of our elementary text-books. S. W. J.

2. *Traité des Matières Colorantes, comprenant leurs applications à la Teinture et à l'Impression, et des notices sur les fibres Textiles, les Epaississants, et les Mordants;* publié sous les auspices de la Société Industrielle de Mulhouse et avec le concours de son Comité de Chimie. Par M. P. SCHUTZENBERGER, Docteur, &c. Paris. (Victor Masson et Fils.) 2 vols. 8vo, avec figures et échantillons intercalés dans le texte.—Though many books have been published on dyeing and printing, there has long been a want of some sound, comprehensive work representing the present state of knowledge respecting these arts. The great work of Persoz, Traité de l'Impression des Tissus, may still be considered as the only full, standard treatise on the subject, but its publication dates so far back that it would require at least a whole volume of *addenda* to bring it forward to the present date. The last twenty years have added something to our knowledge of natural dyes, while most of the numerous artificial colors have been discovered within this period. Many changes have been made in the mixtures used in printing, and new plans have come into use for the subsequent operations. Thus the "aging box" is now made to shorten materially the time required for "aging" goods printed in the "madder style." The aniline colors have made an immense addition to the resources of the dyer and printer. Yet the world has been growing all the while, and these colors have found room for themselves without wholly displacing other things. As gunpowder still holds its own in spite of the extravagant prophecies about gun-cotton, so the enthusiastic hopes of some noted chemists respecting artificial dyes are very far from being realized. It is likely to be a long time before the coal mines of England will supply all the world with all needed dyes. Indigo, cochineal, and madder have lost little of their importance, the colors derived from lichens are still in use, and even carthamus has something more than a historic value.

What is lacking in the older works on dyestuffs is, in a great measure, supplied by the treatise now before us. The author says of the part which he has assigned to himself:—"Le but principal de cet ouvrage est donc la description des matières tinctoriales au point de vue de leurs propriétés chimiques, de leur préparation, et des moyens de determiner leur pureté et leur richesse." He writes not as a compiler making a book out of an indigested mass of clippings from other books, but as one who is himself an investigator, as one who has something fresh to say and knows how to say it in proper compass. In fact he comes up to our expectations of one living at a great industrial center and having the

opportunities, the qualifications, and the rare assistance thus set forth in the preface :—" Onze années passées à Mulhouse comme professeur de chimie pure et appliquée, et comme directeur d'un laboratoire d'enseignment pratique, n'ont permis de réunir les éléments de ce traité. La Société Industrielle, toujours prête à fixer son attention sur tout ce qui est réellement utile, a bien voulu s'interesser au projet de ce travail, et m'offrir le concours effectif de ses lumières. La plupart des articles du premier volume et une partie de ceux du second ont été lus et discutés en séance du Comité de chimie."

We rejoice that it is no longer necessary to plead total ignorance when asked to recommend good, live books on tinctorial science and art. The technological student and the enlightened practical man may here find a really standard, recent work on the subject. It is true that the scientific novice might desire more, and more particular information on some points. Thus the so-called arseniate, silicate, and stannate of soda figure largely in practical printing, and yet one may search books long and almost in vain to find any tolerable account of their actual composition and mode of manufacture. If we examine the articles in the market that work best, we find that the arseniate is not the salt known to chemists by that name, but an anhydrous arseniate neutral to litmus and containing three equivalents of soda to two equivalents of arsenic acid; that the silicate is not the normal salt, but an indefinite waterglass combining one equivalent of soda with from two to three equivalents of silica; that the stannate contains a considerable excess of caustic alkali. For want of accurate knowledge on this last matter, a large establishment that we know of formerly lost several thousand dollars a year by persevering in a vicious mode of manufacturing the stannate, whereby only one-half of the tin used was obtained in solution.

Mr. Schutzenberger passes by the more common chemicals even more hastily than many other writers. But it is some compensation that he thereby gains the more room for other interesting and somewhat novel matter. He dwells much more fully than usual on the fact that such substances as hematin, quercitrin, and brazilin exist in nature as easily soluble glucosids, and not as the disengaged products always described in the books as very slightly soluble in cold water; and so the student will no longer be puzzled to understand why a decoction of logwood or Lima wood may be concentrated to a high degree without depositing the coloring matter. Though each one may find more conciseness on some points than he could have desired, we think on the whole the work will prove to all uncommonly full and satisfactory. J. M. O.

3. *Descriptive Astronomy;* by GEORGE F. CHAMBERS, F.R.A.S. (Clarendon Press Series). Macmillan & Co., London, 1867. 8vo, pp. xl, and 816.—The aim of the writer, who is an amateur astronomer, was to prepare a work that at one and the same time should be attractive to the general reader, serviceable to the student, and handy for purposes of reference to the professional astronomer. Especial pains were taken to present the latest information on all branches of the science.

The work is profusely illustrated, and thus is made quite attractive for popular reading. Notwithstanding the great difficulty of representing such delicate objects as comets and nebulæ by wood-cuts, the artists

and publishers have succeeded remarkably well. The author does not encroach upon the domain of physical and practical astronomy by the use of formulas, as he seems to have most carefully avoided them. For a large class of readers the work would be thus no doubt much more desirable. This is made up to the professional astronomer by the multitude of tables, references, constants, &c., with which the book is crowded. Every person who owns or uses a telescope should have this work. We would call special attention to the chapters on comets, clusters and nebulæ, and celestial photography, and also to the catalogue of celestial objects available for small telescopes. Being prepared by a practical astronomer, he has in general given just that information which is convenient in the observatory. The three chapters on Meteoric Astronomy are, however, unworthy of a place in the book.

4. *Études et Lectures sur l'Astronomie*, par CAMILLE FLAMMARION. Tome I. 18mo, pp. 262. Paris, 1867. (Gauthier-Villars.)—This is a collection of several very interesting articles, written originally for the Cosmos and the Revue Contemporaine, giving the recent progress of astronomical science. The principal subjects are, the Nature and Physical Constitution of the Sun, the Minor Planets, Comets, Eclipses, Terrestrial Magnetism, Shooting Stars, the Nebula and Cosmogony. At the end of the volume is a celestial chart giving the apparent paths of the planets during the year 1867, a device which we heartily commend to almanac makers.

5. *Weights and Measures according to the Decimal System, with tables of conversion for Commercial and Scientific uses;* by B. F. CRAIG, M.D. 48 pp., 16mo. New York, 1867. (D. Van Nostrand.)—A convenient and handsomely printed little manual intended to aid in converting the common weights and measures into those of the French or decimal system and vice versa. The values are given up to 9 multiples, first of the different English weights and measures, with the corresponding values in the decimal system; and then of the decimal weights and measures with the corresponding values in the English weights and measures.

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